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Planning for Cougars in an Urban Environment

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PLANNING FOR COUGARS IN AN URBAN ENVIRONMENT

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ABSTRACT

Urban sprawl is a ubiquitous term and issue for planners across the United States. As sprawl occurs, planners are attempting to impede the effects (loss of biodiversity, increased effects of climate change, increased interaction between wildlife and urban environments) of converting natural spaces to land uses for humans through the integration of green infrastructure. This green movement (conservation/preservation of land, urban tree canopies, open space acquisition) has helped planners alleviate the resource externalities of urban expansion; however, new issues have risen in response.

One issue for planners has been the increased occurrences of wildlife in urban areas. While some of these species are small and often overlooked, the continued habitat degradation has encouraged large carnivorous species to urban environments. Recently, planners are taking action and preparing for co-existence with species such as coyotes and bears with ordinances, urban form, and educations as occurrences rise. The cougar, also called a mountain lion, puma, or catamount, has evoked several high-profile news events for their interaction within the human interface. Currently, the species is primarily managed by federal and state agencies, but as planners continue to deal with presence of the cougar, urban areas are likely to begin planning for the species.

After reviewing the existing literature of cougar management, nine planning strategies were identified for the mitigation of cougar interaction. These strategies were combined in a matrix that can be used for urban planning departments to assess to what degree they are mitigating cougar human interaction.

Twelve urban areas (12 cities with incorporated counties) in the United States were used as a study for the matrix. The findings conveyed many urban areas are using planning strategies to mitigate human cougar interactions; however, they are not intentionally implementing the strategies to mitigate cougar interactions.

DEDICATION

I dedicate this thesis to my family.

To my mother, whose hard work, perseverance, and love have taught me the greatest values of life.

To my sister, who has taught me patience and responsibility.

To my wife, who has provided me enduring companionship and constant inspiration.

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I would like to acknowledge my advisors and committee members who provided insight and guidance throughout the process, Dr. Caitlin Dyckman and Dr. Shari Rodriguez. Their patience, support, and knowledge have been overwhelming and made this research possible.

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CHAPTER ONE

INTRODUCTION

As humans continue to expand their footprint on the earth, human population growth and its associated urban sprawl has caused a conversion of natural spaces to land uses for humans. The ramifications of losing these natural areas have included loss of biodiversity, increased effects of climate change, and more interaction between wildlife and urban environments (Hilty, Lidicker, & Merenlender, 2006; Bateman & Fleming, 2012). These expanded urban areas have forced planners and government officials to resolve the associated problems through policy, education, and built form.

Efforts to address the rapid increase of urban growth and climate change have specifically included developing and integrating forms of green infrastructure into urban form (Benedict & McMahon, 2006). This green infrastructure movement has encompassed large scale changes such as urban tree canopies (Firehock, 2015) and land conservation, as well as small detailed aspects of planning, including green roofs, permeable pavements, and bioswales, it has been adopted at multiple scales, from region-wide to international projects such as Yellowstone to Yukon (YTY) and the Chicago Wilderness.

While this "green movement" is helping planners alleviate the resource externalities of urban expansion and climate change, it has also encouraged and promoted wildlife in urban areas (Bateman & Fleming, 2012). Some urban species are small and overlooked; however, as habitats and their resources erode, large carnivorous species may make their way into urban environments. These species often evoke high profile

news events resulting in government action. Currently, state and federal agencies are primarily managing large carnivorous species through harvesting. But planners are beginning to take notice and prepare for co-existence with species such as coyotes and bears with ordinances, urban form, and education as occurrences continue to rise.

Yet little has been done by planners to account for the felid with the most-extensive, and growing, range in the United States, the cougar (also known as mountain lion, puma, panther, or catamount). Cougar populations appear to be rising in many areas as occurrences are increasing and habitats decreasing. Lately, these occurrences have generated high profile cases such as those involving the first cougar in Connecticut in over 100 years, the cougar titled P-22 who inhabits Hollywood, and the attack of mountain bikers in Washington State. Many states are providing management efforts to mitigate the increasing cougar populations. Currently, 12 states have provided periodical management plans for cougar populations, two states have protected species, and Texas has unregulated hunting on the species. These management techniques have been questioned by some managers, and more efforts have been encouraged such as specified harvesting restrictions, education, cluster development, building code recommendations, and management of urban ungulates and other animals. If planners ignore these recommendations and the species' presence in urban environments, they may risk the safety of and well-being of residents, animals, and property (Johnson, Lewis, Lischka, & Breck, 2018).

To help planners construct policy recommendations I 1) determined strategies planners can implement to better provide co-existence with cougars based on the

literature 2) assessed current urban areas' use of those strategies; 3) determined thematic perceptions of planners' policy and actions for cougar coexistence; 4) compared planners' perceptions to assessment of urban areas 5) provided a framework for planners to promote cougar coexistence within policy and built form.

CHAPTER TWO

REVIEW OF LITERATURE

Urban Planning Problems with Expansion and Growth

Population Growth

Over the past 100 years, the United States has undergone a dramatic increase in human population. In 1910, the United States had a population of 92,228,496. In 2015, the population increased by 247% to 320,090,857. This growth is expected to continue as the total projected population of 2060 is 417 million residents. (U.S. Census Bureau, 1910-2015).

The USDA Natural Resources Conservation Service defines urban and built-up areas as land cover containing residential, industrial, commercial, and institutional land (USDA Natural Resources Conservation Service, 2000). The U.S. Census Bureau classifies urban areas as "densely developed territory, and encompass residential, commercial, and other non-residential urban land uses (U.S. Census Bureau , 2010). Regardless of the variation, both entities indicate that urban populations are growing, and rural populations are decreasing.

According to the U.S. Census Bureau, in 1910 the total rural population was 54.4 percent of the United States population. In 2015, the rural resident population percentage decreased to 19.3%. While the rural population percentage has seen a dramatic decline, it still encompasses 97% of the total area of land within the United States (U.S Census Bureau, 2015). The USDA Natural Resources Conservation service reports that urban

and built-up uses grew by more than 34% from 1980-2000, during a 50 million increase of population (USDA Natural Resources Conservation Service, 2000).

Population and urban growth are not exclusive to the United States. In 2017, the global population is estimated at 7.6 billion people. The world's population has increased by one billion people roughly per decade (United Nations, 2017). As previously mentioned, this population is not only increasing but it continues to move towards urban areas. Nearly 55%, 4.2 billion, of the world's population currently resides in urban areas. It is estimated that this number will increase to 68% by 2050 (United Nations, 2008).

To accommodate this population growth, urban environments are likely to continue their rapid construction rates. Because growth is occurring so fast, new housing, infrastructure, and development are likely to be needed. Urban areas will continue to spread their boundaries and acquire surrounding areas to meet these needs. The United States will have to produce as much as two million housing units annually to keep up with the pace of demand. This expansion will require 30 billion square feet of space to facilitate jobs, housing, and services (Nelson, 2007). Additionally, much of the infrastructure in place must be maintained or replaced due to the use, "result in 70 billion square feet of existing nonresidential space will have to be rebuilt or replaced" (Nelson, 2007). Projections suggest that this will impact every region in the United States (Alig, Kline, & Lichtenstein, 2004). Additionally, the urban growth should encompass double the current amount of urban built form by 2025 (Alig, Kline, & Lichtenstein, 2004).

Energy Consumption and Climate Change

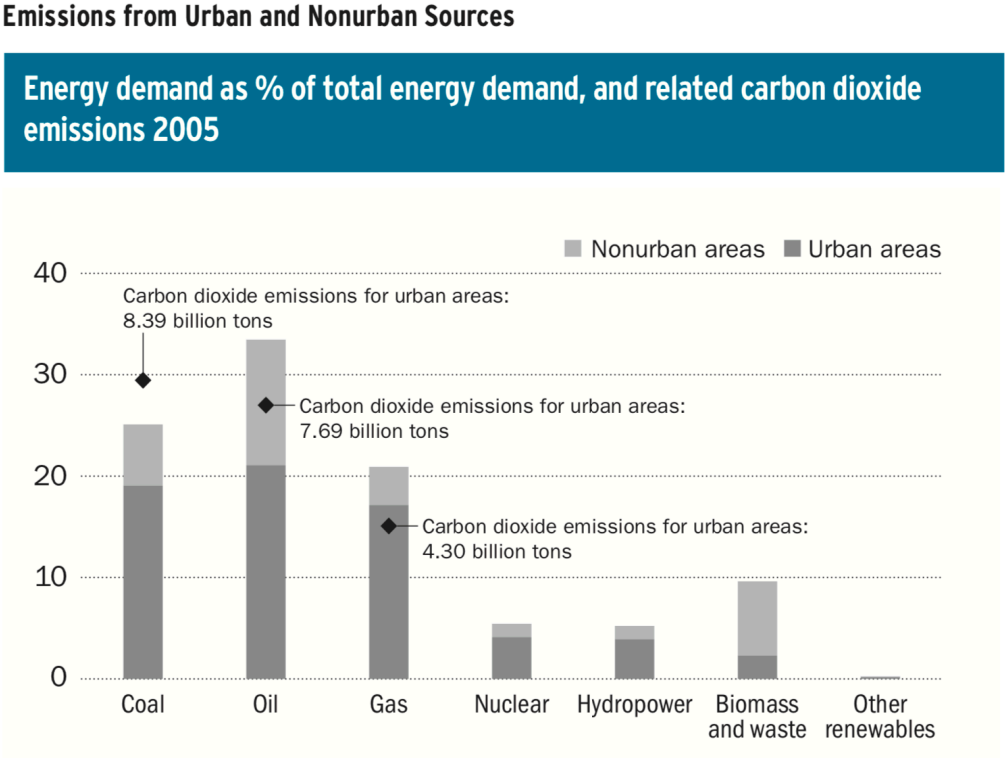
Increased population, urban expansion, and urban maintenance has created some environmental problems for planners. Through these expansions, more residents are consuming energy and accelerating climate change. Some critics may claim population growth and urban expansion themselves are not directly correlated with higher levels of greenhouse emissions. This argument is predicated on the amount of consumption in urban environments, suggesting that population increase, and density may not create more emissions due to several factors (Doddman, 2009). However, United States residents are among the highest in energy consumption (Satterthwaite, 2009). As population increases, the need for development and energy increases. High levels of greenhouse gas emissions are continuing to increase due to the high consumption and growth in consumption. The United States' growth in population and spatial boundaries will continue to foster an increase in climate change caused by exceeding safe emissions levels.

These CO_2 emissions are closely linked to urban environment, population, and economic growth. While the population growth continues to rise consistently, economic growth has dramatically risen and is a much larger contributor to emissions (Satterthwaite, 2009). With this combination of population and economic growth, urban areas will hold 68% of the world's population by 2050 (United Nations, 2008). These urban areas account for a significant portion of the world's total CO_2 emissions as they were responsible for 67-76% of global energy use and 71-76% of energy-related CO2 emissions (IPCC, 2014). This contribution of emissions from urban areas significantly

outweighs the emissions of rural areas (World Bank, 2010). Figure 2.1 shows the difference between emissions of both areas in 2005.

While population growth in urban areas may not directly contribute to emission increases, the ancillary impacts, such as economic growth (fossil fuel consumption, energy use, transportation, development), does increase emissions (Satterthwaite, 2009). The IPCC considers the driving factors for increased greenhouse gasses (GHG) as economic geography, growing cities, urban incomes, technology, infrastructure, many of which are led by the United States (IPCC, 2014). This growth could be concerning as urban areas outweigh rural areas in demand of total emissions as illustrated by Figure 2.1.

Figure 2.1, Emissions from Urban and Nonurban Sources (World Bank, 2010)



The rapid growth of development and populations in urban areas could help climate change accelerate. Without preventative measures, the global mean temperature could increase by 1-4° Celsius or more, before 2100 (IPCC, 2014). Additionally, cities are seeing urban heat islands, which are increased temperatures in specific areas of cities. Urban heat islands can often produce warming trends great or equal to greenhouse gas forced climate changed (McCarthy, Best, & Betts, 2010). The combination of urban surfaces and CO_2 emissions, which are caused by urbanization, show heat events happening in cities across the globe (McCarthy, Best, & Betts, 2010). Climate change and urban heat islands have created higher mortality rates in cities due to extreme heat events (Norton, et al., 2015). In addition to increased climate change, urban environments are seeing poor air quality, increased water runoff, and deteriorating water quality, all attributed to climate change (United States Environmental Protection Agency, 2019).

Land Conservation and Preservation Methods

The increase in urbanization, climate change, and energy consumption have bolstered the need to maintain and increase U.S. land conservation efforts. Conservation efforts in the United States have existed since the 19th century, with the formation of National Parks and Roosevelt's protection of public lands (Theodore Roosevelt and Conservation, 2017). Fueled in part by the public's interest in naturalist writing (Leopold, Carson, etc.) , the federal government issued an array of conservation efforts during the 1970's with legislation like the Wilderness Act (Wilderness Act, 1964), Endangered Species Act (Endangered Species Act, 1973), and Clean Water Act (Clean Water Act, 1972). This continued later in 20th century with the Farmland Protection Policy Act

(Farmland Protection Policy, 1984). In the early part of the 20th century, the primary conservation efforts were through government land acquisition. However, due to the swift growth of urban environments, this method became fiscally and socially untenable. Following the introduction of the Environmental Policy Movement (1960s), a backlash occurred on government's command and control style and the acquisition of public lands (Owley, 2005). In the late 1970s, conservation easements were created to protect scenic routes and habitat (Gustanski & Squires, 2000). Conservation easements remained relatively unpopular until the 1980s and federal tax incentives for their use. Private owners and conservation agencies began using conservation easements to protect land in response to government bureaucracy, the high cost of government land acquisition and management, grid-lock between land agencies, and sensitivity toward government control (Merenlender, Huntsinger, Guthey, & Fairfax, 2004).

While conservation easements are found in all states, they vary in name and definition (Gustanski & Squires, 2000). Generally, conservation easements are regarded as "a contract that divides portions of land title between the land owner, or feed holder, and easement holder." (Merenlender, Huntsinger, Guthey, & Fairfax, 2004). They can also be called: conservation restriction, preservation restriction, agricultural preservation restriction, or land use easement (Gustanski & Squires, 2000). Conservation Easements permit property owners to sell or donate their development rights while maintaining a title to the underlying property (Gustanski & Squires, 2000). Because they provide property owners with flexibility and monetary benefits, in addition to providing

conservationists an easier path to conserving land, conservation easements have seen a significant increase of use.

Currently, there are an estimated 158,168 conservation easements in the United States, with the majority being located in the northeastern states (National Conservation Easement Database, 2018). While the validity and certainty of this information has been questioned, the data suggests a growing trend in easement use and protection (National Conservation Easement Database, 2018). While the National Conservation Easement Databases estimates are contested, other studies are showing the growth of easement protection growing exponentially (Fishburn, Kareiva, Gaston, & Armsworth, 2009). In 1998, 1.4 million acres were protected by conservation easements (Gustanski & Squires, 2000). Additionally, the largest land trust in the United States appears to show that investment of funds is positively correlated with the growth of conservation easements (Fishburn, Kareiva, Gaston, & Armsworth, 2009).

This growth in conservation has been facilitated by land trusts, usually acquiring easements to conserve land while not obtaining the full rights of property (Merenlender, Huntsinger, Guthey, & Fairfax, 2004). The drastic increase may signify the private markets efforts to alleviate the federal government's role, it may also signify the observation of fast urban growth by local governments and non-profit organizations. In an effort to provide open space, views, property values and habitat, local governments and land trusts are conserving land with private land-owners. It is important to note that many conservation easements are not biologically oriented; however, their preservation may result in these benefits.

Green Infrastructure and Planning

Realizing that conservation efforts, alone, cannot solve the problems of urbanization, there has been a large effort to make urban environments more "green". Urban planners and city officials have followed the green initiative through green infrastructure. Like conservation efforts, green infrastructure is attempting to alleviate the urbanization externalities i.e. loss of land and climate change. However, green infrastructure differs from conservation efforts in that it partners man-made infrastructure planning and land-development to delineate the effects (Benedict & McMahon, 2006).

Green infrastructure may have several definitions, but its ultimate goal is often the same. According to the EPA, "Green infrastructure is a cost-effective, resilient approach to managing wet weather impacts that provides many community benefits" (United States Environmental Protection Agency, 2018). Others see green infrastructure as a mode of connected green spaces (Benedict & McMahon, 2006; Firehock, 2015). The significant difference appear to differ in what variable is being managed. The EPA's strict definition deems water as the primary variable, while others provide a broad definition encompassing land, air, and water management techniques. Thus, an all-encompassing definition of green infrastructure is a framework to incorporate natural resource techniques to mitigate the effects of urbanization. This movement has permeated all scales of development and is incorporated in various stages of building.

Urban forests, a form of green infrastructure, may increase a city's air quality, habitat connectivity, and decrease flooding. Cities like Chicago and New York have found that installing urban tree canopies removes large quantities of greenhouse gasses and "saves taxpayers millions in pollution mitigation" (Benedict & McMahon, 2006). These trees and their soils help reduce runoff pollutants, break the energy of rain, reduce intensity of runoff, and absorb greenhouse gases (Firehock, 2015). These trees can also provide habitats for wildlife but require 100 acres of native tree species to support a diverse environment (Firehock, 2015). Tree canopies are also ideal for reducing temperatures. By providing shade, solar reflection, and evapo-transpirative cooling, urban tree canopy can reduce help alleviate the urban heat island effect (Norton, et al., 2015).

Green infrastructure efforts have also been made to create networks of linked urban green spaces, in an effort to provide "smart conservation". By utilizing green infrastructure networks, cites tie together built form and conserved natural areas to form a connected ecosystem and landscape. Using a system of hubs, links, and sites, cities provide space for wildlife, people, and ecological processes (Benedict & McMahon, 2006). These networks must utilize several types of Green Infrastructure that may include: greenways, greenbelts, parks, wildlife corridors, forests, farms, and view sheds. By creating the network, cities have been able to start combating remote climate increase, flooding, and habitat fragmentation. Open space, littered with trees, can provide "cool" areas for people to congregate with shade, downwind, and reflect solar rays (Norton, et al., 2015).

Hostetler, Allen, and Meurk suggest that cities should/can provide a green multi-scale approach (Hostetler, Allen, & Meurk, 2011). Establishing green infrastructure and promoting policy that ensures low impact development through incentives could conserve urban biodiversity as well (Hostetler, Allen, & Meurk, 2011). But green infrastructure has also been criticized for being narrowly focused on run-off water mitigation, or unfeasible projects (Hostetler, Allen, & Meurk, 2011). By incorporating simple tasks such as green façade and small green lots, cumulative green infrastructure efforts can contribute to a larger area of conservation (Hostetler, Allen, & Meurk, 2011).

Green Space Connectivity

Additionally, by providing efforts like wildlife corridors in conjunction with cumulative green infrastructure urban areas may be able to combat issues caused by climate change. These areas are often part of the multifunctional landscape framework and have been promoted by cluster developments, open space, wet-land stormwater management techniques, and retention of native plants (Randolph, 2004).Whether intentional or not, the landscapes created by green infrastructure are providing habitat. As the urban environment spreads, edges and ecotones of wild and rural areas are converging with urban environments. The green infrastructure may protect the local ecosystems and habitat of the present wildlife (Hilty, Lidicker, & Merenlender, 2006).

Through both conservation and infrastructure, the urban environment is providing green spaces that promote the conservation of habitat and utilize the benefits of green infrastructure. Green infrastructure is protecting the urban environment from issues like heat and flood, while also providing a natural habitat for native plant and animal species.

Areas like the Chicago Wilderness have been created on the vision of green infrastructure (Chicago Wilderness, 2018). The project's goals help ensures economic value, mitigation, and conservation (Chicago Wilderness, 2018). This collaboration between cities and conservationists may facilitate an opportunity for planners to appeal to a wider array of people in protecting valuable land.

Conservation Biology Problems with Urban Expansion and Growth

Habitat Loss

Conservation biologists, landscape ecologists, and wildlife managers are also dealing with the ramifications of urban expansion. Wildlife habitats reduction are in direct correlation with the expansion of urban growth and population. Because of the observed decline in habitats or connected habitats, researchers are focused on identifying and alleviating the issue (McCance, 2017).

Habitats consist of several attributes: food, water, space, and protection (Randolph, 2004). While all species require these attributes, some have larger demands for each. Habitats are classified by their plant community type as they provide the attributes for the habitat (Randolph, 2004). Biodiversity measured by species count and variety increases with larger habitat areas. Edges, "different plant communities or successional stages come together", and ecotones, "different communities stages overlap or intersperse", provide greater plant and animal diversity (Randolph, 2004, p. 556). Although ecotones and edges provide areas of more diversity, they do not always provide an adequate size for some plants and animals.

Biodiversity facilitates a healthy habitat, but habitats have been succeeding to land-use changes for the past century. The loss and fragmentation of these habitats reduces the size of habitat thus reducing the biodiversity (plant and animal loss) (Genua, Start, & Gilbert, 2017). This threat is regarded as the "primary proximal" threat to diversity of species (Crooks & Sanjayan, 2006, p. 7). Species that have large ranges are often affected the most and need properly connected areas to survive. While species requiring large populations may exist today, they are not sustainable with the predicted urban expansion's effect on food, shelter, and size of habitat (Hilty, Lidicker, & Merenlender, 2006).

As habitats are encroached upon by urban sprawl, the ecotones and edges are the first to be affected. When urban growth removes edge habitats, it can create a plethora of effects on a region's biodiversity and ecosystems. However, these effects are not always directly visible; there can be subtle impacts climate, wind exposure, direct sun, and increased snow loads (Hilty, Lidicker, & Merenlender, 2006). These threats can be intensified by the effects of climate change. Rising temperatures have shown to greatly affect species such as trees, reducing their time to adapt and changing the habitat (Kolbert, 2014). Additionally, climate change can increase the chances for habitat destruction through fire and flooding. These stressors elevate the risk of mortality to species.

Habitat Connectivity

To truly determine if a wildlife habitat is fragmented, we must define connectivity. Because the topic is embedded in biology, planning, architecture, and

engineering, an array of landscape connectivity definitions have been created. Some definitions are specific and detailed, while others are broad and all-encompassing (Taylor, Fahrig, Henein, & Merriam, 1993). Crooks has determined most definitions of landscape connectivity have two key components: structural and functional (Crooks & Sanjayan, 2006). The structural components convey the spatial arrangement of various habitats and other variables within a landscape. Where functional components identify behavioral responses of specific species of ecological processes to the physical structure (Crooks & Sanjayan, 2006). These two components of connectivity have been difficult to maintain due to the urban expansion, climate change, and other anthropogenic influences.

Habitat Fragmentation and Destruction of Diversity

Fragmentation by development is often irreversible. As development divides habitats, they become isolated and prone to more complications (Crooks & Sanjayan, 2006). Isolated fragments with no connectivity are often expected to receive the most intense effects (Frankham, 2006). Lack of connectivity prevents exposure to a diverse genetic flow, leading to inbred populations and increasing their extinction risks (Frankham, 2006). Low diversity affects extinction through interbreeding depression, loss of genetic variation, and reduced ability to adapt to environmental change, etc. (Frankham, 2006). Isolated populations are often genetically differentiated (known as genetic drift), which could increase the time of their demise (Alberti, Marzluff, & Hunt, 2017; Frankham, 2006). Because of their isolation, they become differentiated from other fragments and cannot reproduce as other populations (Frankham, 2006).

Patches or fragments that are partly connected face similar risks to areas without connectivity. Fragmentation leaves patches of communities behind; however, the number of patches is generally reduced as original community is depleted (Hilty, Lidicker, & Merenlender, 2006). Smaller habitats are also more susceptible to disease and natural disasters, which can threaten species. Partially connected habitats do have the potential to survive pending the results of the following: number of population fragments, distribution of population within fragments, geographic distribution, ability to travel, susceptibility of inbreeding depression, and the reproductive success of migrants to different types of fragments (Frankham, 2006). Because connected habitats require many variables for success, long-term survival is unlikely to occur. This is especially concerning because every species has differing responses to issues like fragmentation or accessibility.

If a habitat is poorly connected or isolated, a trophic level in the food web can be limited and increase the risk of extinction of many species (Hilty, Lidicker, & Merenlender, 2006). Trophic cascade is an ecologic concept where a disturbance at one trophic level impacts other trophic levels (Lindeman, 1942). They were first observed when Aldo Leopold conducted a survey of deer populations across the United States; Leopold determined that the removal of wolves, altered the deer population's behavior and count (Leopold, Sowls, & Spencer, 1947). Without predators, deer populations began consuming all of their resources, resulting in famine and death. This idea was expanded when keystone species were identified as a requirement for a stable ecosystem (Paine, 1969) and when trophic links were identified to be stronger in certain animals (Paine, 1980). Although much of the initial research of trophic dynamics has been conducted in

aquatic environments, they have been identified in a vast array of habitats (Pace, Cole, Carpenter, & Kitchell, 1999).

Now that urban expansion is isolating and fragmenting patches, it becomes difficult for many keystone species and trophic links to exist (Genua, Start, & Gilbert, 2017). Many large predators, most of which are keystone species, need connectivity to large core habitats for survival. A keystone species' lack of proper connectivity habitat keeps the species from functioning normally in the trophic-dynamic (Lindeman, 1942). The need for them to compete against other species is significant; their absence greatly alters the demographic behaviors of other species (Hilty, Lidicker, & Merenlender, 2006). This could result in species extinction, decreased plant biomass, and the overall ultimate plant fitness (Genua, Start, & Gilbert, 2017). Even if these species manage to survive in a small patch the reduced predator density increases the risk of stochastic extinction of predators (Genua, Start, & Gilbert, 2017), resulting in the absence of a trophic level.

Protection of Habitats and Diversity through Built Form and Policy

Efforts have been implemented to connect large habitats (core habitats) through corridors. Habitat corridor planning is designed to provide core habitat in an urban matrix, buffers between core habitats connectivity through corridors (Randolph, 2004). This provides a wide range of animal paths for travel and a means of mitigating of negative factors. It allows plants to propagate, permits animals to adapt to environmental changes, and creates space through which migrating animals can locate new areas (Randolph, 2004).

Corridors facilitate biodiversity function, but some experts argue that the corridors do not actually promote the intended movement. Connectivity should be evaluated through various methods: structural, potential, and actual connectivity (Fagan & Calabrese, 2005; Theobald, 2005). Fagan & Calabrese's methods analyze data in hopes to identify proper use and connectivity of a specific species (Fagan & Calabrese, 2005). Each method refers to a potential reasoning for establishing a corridor. However, it appears that each case should be evaluated on its own merits, as each species have varying connectivity requirements. Failures of habitat corridors often include: lack of proper size, ill-suited form, restrictive use, and limited funds (Randolph, 2004). If planners are designing areas to promote these open space areas, whether intentional or not, through green infrastructure, they should take these factors into consideration before creating or implementing in a comprehensive plan.

Efforts to protect habitats and species go back to conservation efforts in the 19th century. More recently, the Endangered Species Act (ESA) of 1973 provided a legal obligation to monitor and protect endangered species and their habitats. This program permits any United States citizen to petition the protection for a plant or animal species. If a species is listed, then the species' "critical habitat" cannot destroyed or adversely modified (Endangered Species Act, 2018). While the program does provide protection services for species and habitats, its approach is often labeled as cumbersome and vague (Eisenberg, 2014). Three years prior to the ESA, the National Environmental Policy Act (NEPA) was adopted to ensure that "federal agencies…assess the environmental effects of their proposed actions prior to making decisions." (National Envrionmental Policy

Act, 2017). NEPA's procedural format in combination with ESA's substantive format can provide strict restrictions on habitat conservations.

These laws, while restrictive, can only enforce on a federal level. If a species is not listed on the ESA, the state may elect to create their own law or choose to ignore a species and its habitat. Likewise, NEPA can only mandate studies upon federal agencies' projects. This potentially hinders the protection of species that have large ranges, like carnivorous predators, crossing state or federal boundaries. An example of this would be the gray wolf. In 1974 the gray wolf was listed as "endangered" by the ESA. After 30 years of protection and recovery, it was downlisted to "threatened" (Eisenberg, 2014). This species habitat, the Northern Rocky Mountains, had states with varying management regulations and state policies to protect predators (Eisenberg, 2014). This could result in fragmentation of the species' habitat or population loss. While it could be petitioned to be "endangered", enacting protection across the country would take considerable time, and may be too late to protect the animals.

New Issues from Human Encroachment on Predator Wildlife

Behavioral Changes in Large Carnivorous Predators

The conversion of wildlife-habitats into urban land uses has generated an array of new issues for urban planners, developers, and the general population. As previously mentioned, edges and ecotones often provide more biodiversity and are often the first to be consumed by human development. When these areas are removed, some species may move into urban environments more often (Johnson, et al., 2015; Benedict & McMahon, 2006). This is against the norm for some wildlife that may respond to risk-reward

behaviors by avoiding human-dominated landscapes (Merkle, Robinson, Krausman, & Alaback, 2013). Large predators, usually more sensitive to habitat fragmentation, may be visiting urban environments and the edges (Bateman & Fleming, 2012; Moss, Alldredge, & Pauli, 2016; Knopff, Knopff, Boyce, & St. Clair, 2014; Maletzke, et al., 2017; Kerston B. N., Spencer, Marzluff, Hepinstall-Cymerman, & Grue, 2011). Habitat loss and diminishing prey conditions have large carnivores, particularly pushed bears, cougars, and wolves, into these areas.

Large carnivores typically are not considered urban dwellers; however, anthropogenic habits have drawn them to these areas. Urban environments provide reliable, high nutrient food to these animals (Bateman & Fleming, 2012). Human refuse has attracted wolves to urban environments (Bateman & Fleming, 2012), vacant vacation homes has drawn bears to unoccupied areas (Merkle, Robinson, Krausman, & Alaback, 2013), and accessible prey is abundant for felids (Bateman & Fleming, 2012; Moss, Alldredge, & Pauli, 2016). Food sources associated with people in urban environments such as livestock, rodents, pets, and road kill continue attracting large predators (Bateman & Fleming, 2012; Moss, Alldredge, & Pauli, 2016).

Despite the allure of food, some literature suggests that these large predators are still hesitant to venture into human dominated areas because of the high mortality risk (Bateman & Fleming, 2012; Knopff, Knopff, Boyce, & St. Clair, 2014). If the occurrences of bears, wolves, and mountain lions increase in developed areas, why have these species ignored the risks? It likely is dependent upon the individual species' hunger state (Blecha, Boone, & Alldredge, 2018).

Predators tend to show attraction to land areas where more prey is available (Blecha, Boone, & Alldredge, 2018). The foraging habitats of bears and cougars may be changing as urbanization increases. Merkle et al (2013) found that bear populations in Montana were attracted to human foods in urban feeding sites, whereas wildland food within the feeding sites only attracted a small portion of bears. The bears were observed to shift their foraging habits to night, specifically to avoid humans and decrease their risk of death. Similarly, Blecha, Boone, and Alldredge (2018) found cougars, whose habitats were destroyed, altered their feeding habits. As the cougar's prey became more dispersed, the cougar's risk avoidance decreased in more urbanized settings. Dispersed prey makes it difficult for cougars to hunt and increases the desire for food, resulting in the species ignoring its traditional risk avoidance behavior (Blecha, Boone, & Alldredge, 2018). Moss, Alldredge, and Pauli (2016) found that when this behavior changes it also alters their diet, 63-83% of their diet consisted of active herbivores, while 20% or more of the diet comes from alternative prey like synanthropic wildlife and domesticated species. Typically, cougars would avoid these prey because of the increased threat of death; however, they appear to be ignoring mortality risks as large as 6.5% per 10% increase in density (Moss, Alldredge, & Pauli, 2016).

Additionally, researchers are finding that cougars are not only encroaching on fringe urban environments more often but are needing more food when in developed areas (Wang, Smith, & C., 2017). After analyzing the large carnivore's responses to anthropogenic disturbances, cougars exhibited higher energetic costs and resource requirements in human dominated lands (Wang, Smith, & C., 2017). The proximity of

housing and anthropogenic disturbances like light and noise pollution causes cougars to increase their caloric expenditure (Wang, Smith, & C., 2017). To compensate, it is estimated that cougars need to kill an average of 3.4 – 4.0 deer more annually. This need, coupled with dispersed prey and reduced habitat, could increase the probability of cougars continuing to encroach on human-dominated environments. Some theories suggest that cougars are now using a method called "dine and dash", catching smaller prey to reduce the caloric expenditure required to take a larger prey species (Blecha, Boone, & Alldredge, 2018). These dietary shifts could be proportionate to the abundance of certain prey (Moss, Alldredge, & Pauli, 2016). Other studies suggest cougars are spending less time at kill sites and abandoning their prey at a higher rate in developed areas (Kerston B. N., Spencer, Marzluff, Hepinstall-Cymerman, & Grue, 2011). Some studies are showing that large carnivores are becoming resilient and changing to the developed habitat (Moss, Alldredge, & Pauli, 2016).

While in developed environments, cougars are also shifting habits of hunting. During the day they are more likely to stay away from roads and buildings, using connected greenspaces and forests (Knopff, Knopff, Boyce, & St. Clair, 2014; Maletzke, et al., 2017; Moss, Alldredge, & Pauli, 2016). During the night, they use the opposite areas for hunting and movement (Knopff, Knopff, Boyce, & St. Clair, 2014; Moss, Alldredge, & Pauli, 2016; Maletzke, et al., 2017). As they approach greater housing densities, they are more likely to stay within the fringe areas (Maletzke, et al., 2017). This may indicate that cougars are both avoiding human areas and following ungulates that are found in these urban areas (Knopff, Knopff, Boyce, & St. Clair, 2014). These trends

suggest that more development near a cougar's habitat may result in less anthropogenic features avoidance, but cougars in areas with less development nearby may be more likely to avoid these human dominated areas (Knopff, Knopff, Boyce, & St. Clair, 2014).

Evolutionary and Phenotypic Changes of Species

Species evolution and adaptation is already being forced by climate change (Hilty, Lidicker, & Merenlender, 2006; Johnson, et al., 2015) and the fragmentation of their habitats (Frankham, 2006). Animals like grizzly bears are finding climate change influencing their birth rates (Eisenberg, 2014), while black bears are changing their sleep cycles (Bateman & Fleming, 2012), and mountain lions have more dietary requirements (Wang, Smith, & C., 2017). Now, through urban exposure and human affects, species may be exhibiting micro-evolutionary changes (Alberti, Marzluff, & Hunt, 2017). Hypotheses have been formed suggesting that urban environments force these phenotypic changes to speed up and that non-urban and urban populations are beginning to differentiate (Alberti, Marzluff, & Hunt, 2017). In combination with urban exposure, studies may find change happening even faster. Urbanization is driving phenotypes in five ways: habitat modification, biotic interactions, heterogeneity, novel disturbance, and social interactions (Alberti, Marzluff, & Hunt, 2017). Examples of change include elongated beaks, wingspan change, and densities of earthworms (Alberti, Marzluff, & Hunt, 2017).

The spread of urban environment and its effects on wildlife habitat have created changes in the environment and species. Expecting the various species to adapt to their changing world and abstaining from the human world may be a difficult task.

New Urban Growth in the United States

The difficulty of mitigating the effects on wildlife habitat by urban growth is becoming increasingly more difficult as planning departments, state agencies, and non-profit organizations are dealing with urban expansion across the United States. The entire country has seen a drastic population increase since the early 20th century, as previously mentioned. However, southern and western states have seen the largest percentage and total population increase from 2016 to 2017

Figure 2.2, Top 10 States in percentage and total growth 2016 to 2017 (U.S. Census Bureau, 2018)

Top 10 States in Percentage Growth: 2016 to 2017

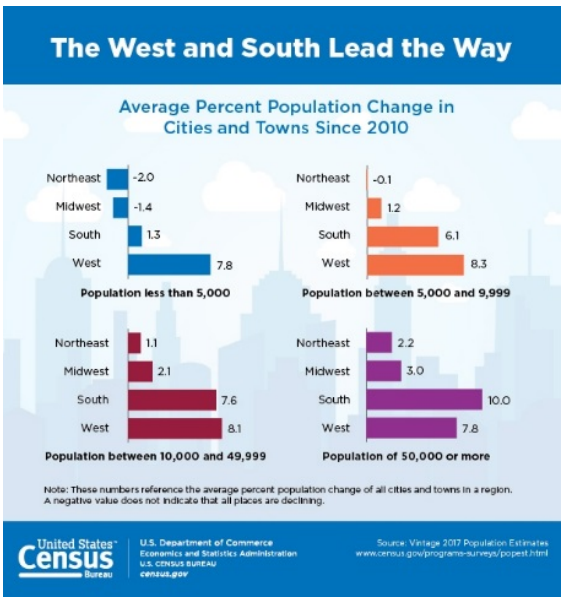
Rank	Name	2010	2016	2017	Percent growth
1	Idaho	1,567,650	1,680,026	1,716,943	2.2
2	Nevada	2,700,691	2,939,254	2,998,039	2.0
3	Utah	2,763,889	3,044,321	3,101,833	1.9
4	Washington	6,724,545	7,280,934	7,405,743	1.7
5	Florida	18,804,594	20,656,589	20,984,400	1.6
6	Arizona	6,392,309	6,908,642	7,016,270	1.6
7	Texas	25,146,100	27,904,862	28,304,596	1.4
8	District of Columbia	601,766	684,336	693,972	1.4
9	Colorado	5,029,325	5,530,105	5,607,154	1.4
10	Oregon	3,831,072	4,085,989	4,142,776	1.4

Top 10 States in Numeric Growth: 2016 to 2017

Rank	Name	2010	2016	2017	Numeric growth
1	Texas	25,146,100	27,904,862	28,304,596	399,734
2	Florida	18,804,594	20,656,589	20,984,400	327,811
3	California	37,254,518	39,296,476	39,536,653	240,177
4	Washington	6,724,545	7,280,934	7,405,743	124,809
5	North Carolina	9,535,721	10,156,689	10,273,419	116,730
6	Georgia	9,688,690	10,313,620	10,429,379	115,759
7	Arizona	6,392,309	6,908,642	7,016,270	107,628
8	Colorado	5,029,325	5,530,105	5,607,154	77,049
9	Tennessee	6,346,295	6,649,404	6,715,984	66,580
10	South Carolina	4,625,381	4,959,822	5,024,369	64,547

In addition to the overall state growth, urban environments containing populations of 10,000 or greater have also seen their largest growth in southern and western states (*Figure 2.3*).

Figure 2.3, West and Southern States Population Growth (U.S. Census Bureau, 2018)



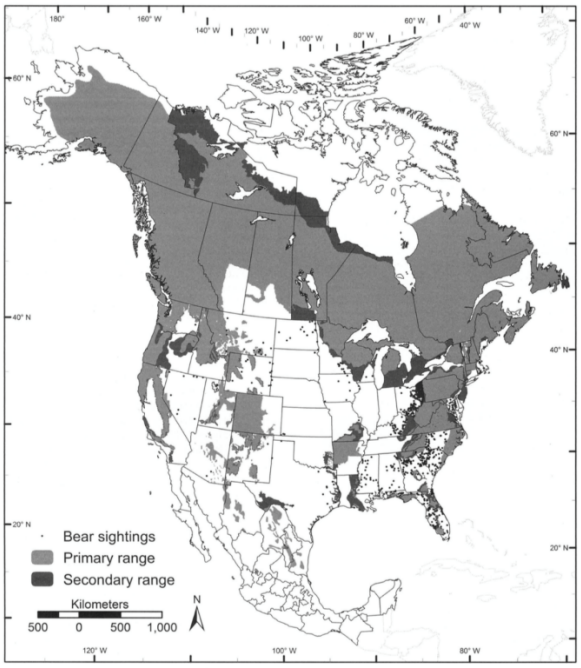
As urban areas' populations increase in the western and southern United States, it should be expected that the boundaries of the urban areas expand. This urban increase is thought to have increased effects on climate change and habitat fragmentation. The increased density and boundaries of urbanization in these areas may be removing the habitat of America's remaining large carnivorous predators.

Large Carnivorous Predator Habitat Destruction

Habitat fragmentation and climate change often have the most effects on large carnivorous predators or keystone species. These species can require large connected habitats that provide adequate resources. Biologists studying fragmented habitat have identified that the loss the keystone species could result in a trophic cascade. This extinction could be led by an array of stressors and attributes correlated with the reduction of habitat.

The black bear currently resides within a large portion of the North America as seen in Figure 4. This range accounts for 40% of the total land in the United States (Scheick & McCown, 2014). The total North American population of the American Black Bear is estimated between 850,000 – 950,000, with increasing populations in most states. (Garshelis, Scheick, B.K., Beecham, & Obbard, 2016).

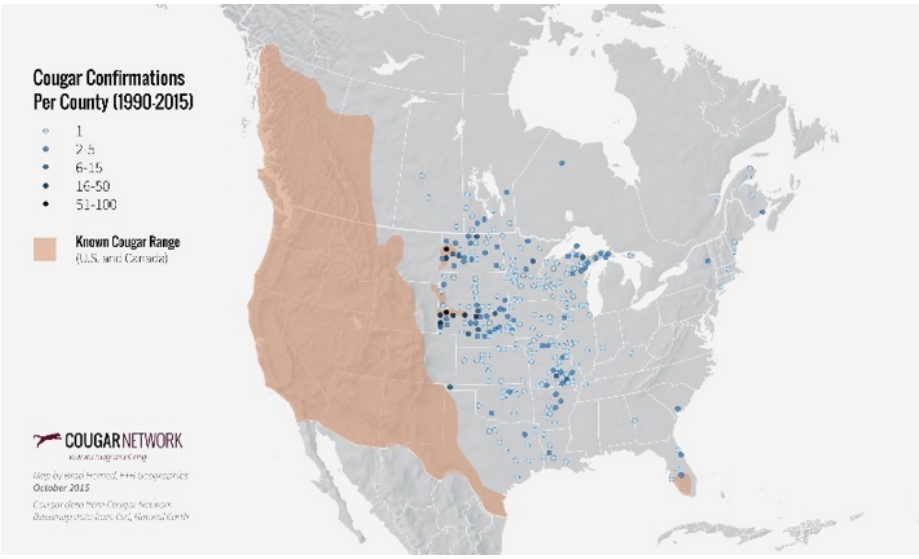
Figure 2.4, Range of Black Bear (Scheick & McCown, 2014)



The cougar has the greatest range of all felids, as it encompasses many countries in North America. They can be found in an array of habitats, adapting to areas where shelter and prey are provided (National Wildlife Federation, 2019). While the Eastern Cougar was officially declared extinct in 2011 by the U.S. Fish and Wildlife Service, it was effectively extirpated in the early 1900s. *Figure 2.5*, illustrates the current habitat of all subspecies of cougars within the United States and Canada (Cougar Network, 2015). The habitat primarily exists in the west with a small population of a sub-species in

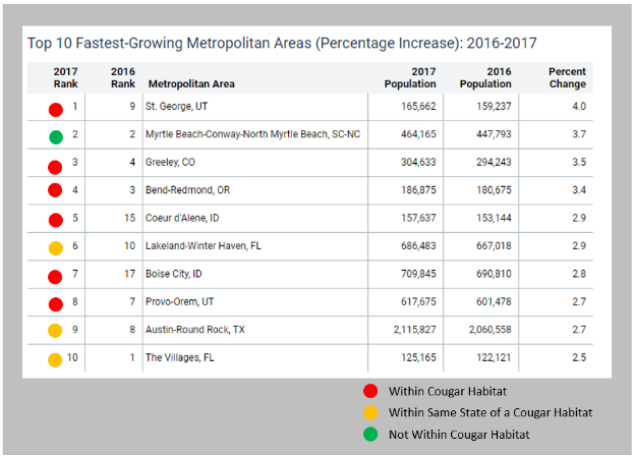
Florida. Currently, viable populations exist in 16 states as seen in *Figure 2.5* (Cougar Fund, 2018). These areas used by the cougar are amongst the highest growing urban areas. The expansion of both urban areas and cougar habitat across Texas and middle America could result in an increase of interaction between cougars and humans as humans and cougars are inhabiting the same areas.

Figure 2.5, The current cougar range within the United States and Canada (Cougar Network, 2015)



The cougar's range expansion happens to coincide with human expansion into the same regions. Much of the current range is within the same state as many of the fastest growing areas of the United States. In 2017, nine of the fastest growing Metropolitan Statistical Areas (MSA), by percentage, were within a state of the cougar's current range, while six of those MSAs are already within the cougar's current range. This trend follows the fastest growing MSAs by numeric value, fastest growing states (both percentage and numerical growth), and fastest growing counties (both percentage and numerical growth) (U.S. Census Bureau, 2018).

Figure 2.6, Fastest growing urban areas in the United States, with a self-created label of cougar habitat, non-cougar habitat, or within state with a cougar habitat (U.S. Census Bureau, 2018)



Top 10 Fastest-Growing Metropolitan Areas (Percentage Increase): 2016-2017

2017 Rank	2016 Rank	Metropolitan Area	2017 Population	2016 Population	Percent Change
1	9	St. George, UT	165,662	159,237	4.0
2	2	Myrtle Beach-Conway-North Myrtle Beach, SC-NC	464,165	447,793	3.7
3	4	Greeley, CO	304,633	294,243	3.5
4	3	Bend-Redmond, OR	186,875	180,675	3.4
5	15	Coeur d'Alene, ID	157,637	153,144	2.9
6	10	Lakeland-Winter Haven, FL	686,483	667,018	2.9
7	17	Boise City, ID	709,845	690,810	2.8
8	7	Provo-Orem, UT	617,675	601,478	2.7
9	8	Austin-Round Rock, TX	2,115,827	2,060,558	2.7
10	1	The Villages, FL	125,165	122,121	2.5

Within Cougar Habitat
Within Same State of a Cougar Habitat
Not Within Cougar Habitat

Wildlife Management and Lack of Urban Management

While the expansion of urban areas in cougar habitats could cause an increase in human cougar interactions, this could be prevented if humans designated habitat areas for cougars with sufficient food resources (Bateman & Fleming, 2012). Because cougars naturally avoid human dominated landscapes, providing space and food could create the needed balance. But, Johnson, et al (2015) says climate change's impact on habitats and food resources could increase the pace of habitat destruction and increase the likelihood of appearances of large animals foraging for human resources. Their research suggests that lack of adequate prey base may increase foraging of urban development.

When large carnivores foraging for food enter the urban environment a common management strategy is to physically remove the animal from the urban environment. Other strategies include translocation, culling, hazing, aversive conditioning, and education (Johnson, Lewis, Lischka, & Breck, 2018). These strategies can cull

populations; however, they can be hindered by efficiency, time, and money (Johnson, Lewis, Lischka, & Breck, 2018). Additionally, they constitute a proximal solution that inadequately addresses the issue (Johnson, Lewis, Lischka, & Breck, 2018). These strategies are usually implemented by state and federal wildlife agencies, but financial and logistical hindrances often lead to voluntary efforts (Johnson, Lewis, Lischka, & Breck, 2018).

Bears have been an ongoing issue for urban environments because of their broad range and large population. Developed and urban areas have seen increases of bear activity for many years and have pushed researches, state agencies, and planners into extensive preventative methods. These management techniques have included a wide array of methods, from small design standards of trash cans to policy mandating resident cleanliness (Lackey, Breck, Wakeling, & White, 2018; Gore, 2004). Urban planners and non-profit organizations have tried to reduce anthropogenic activities that draw bears to urban areas. Organizations like BearWise and BearSmart provide information, policy recommendations, and design standards to urban planners to better mitigate human-bear contact (BearWise, 2019; BearSmart, 2018). However, most management is still operated and managed through state and federal agencies (Lackey, Breck, Wakeling, & White, 2018).

Likewise, cougar management has been primarily the role of state and federal agencies. Currently, 13 states have adopted periodical state cougar management plans. Florida's cougars are protected by the Endangered Species Act and California issued Proposition 117 in 1990 that eliminated hunting and protected the species. Texas

currently considers the cougar as a pest and it does not manage or monitor hunting (Cougar Fund, 2018).

The primary method for states with management plans are to issue harvesting quotas. This method is based upon the "source-sink" concept, which suggests that in order to maintain a healthy habitat a population threshold should be met (Beausoleil, Koehler, Maletzke, Kerston, & Wielgus, 2013). However, many studies suggest that open harvesting may not be appropriate or successful in mitigating interactions with humans or developed areas (Kerston, Spencer, & Grue, 2013; Kerston B. N., Spencer, Marzluff, Hepinstall-Cymerman, & Grue, 2011; Beausoleil, Koehler, Maletzke, Kerston, & Wielgus, 2013; Hiller, Mcfadden-Hiller, Jenkins, Belant, & Tyre, 2015; Stoner, Wolfe, & Choate, 2006). While higher cougar populations increase the likelihood of conflict with livestock (Hiller, Mcfadden-Hiller, Jenkins, Belant, & Tyre, 2015), harvesting may be counterproductive and encourage younger cougars to find livestock as a suitable prey.

Greater cougar density may increase human conflicts with wildlife, but several reports have suggested that cougar harvesting is not effective for deterring interactions (Hiller, Mcfadden-Hiller, Jenkins, Belant, & Tyre, 2015). It is used as a short-term population reduction process that has not been demonstrated to reduce predation (Cougar Management Guidelines Working Group, 2005). Harvesting is one of the older management techniques, for managing predator populations, with the objective to alleviate the destruction of undulates that are typically reserved for sport hunting and reduce conflict (Teichman, Christescu, & Darimont, 2016). Harvesting is based on the theory of source-sink, attempting to maintain and stabilize a habitat (Beausoleil, Koehler,

Maletzke, Kerston, & Wielgus, 2013). Using this theory, management agencies typically select harvesting quotas, or a specific number of animals to be killed. These harvesting quotas are sometimes selected by the number of complaints received on cougar sightings and interactions (Beausoleil, Koehler, Maletzke, Kerston, & Wielgus, 2013). But these quotas can disregard spatial ecology (Kerston B. N., Spencer, Marzluff, Hepinstall-Cymerman, & Grue, 2011). Killing cougars creates vacancies in a territorial area, if a viable habitat, meaning that other cougars will immigrate and enter the area in attempts to claim it (Kerston B. N., Spencer, Marzluff, Hepinstall-Cymerman, & Grue, 2011; Stoner, Wolfe, & Choate, 2006; Teichman, Christescu, & Darimont, 2016). Additionally, the selection of harvested (hunted) cougars are for trophy which can encourage larger and older cougars to be killed (Stoner, Wolfe, & Choate, 2006; Teichman, Christescu, & Darimont, 2016). This generally promotes younger and smaller cougars to migrate to the area.

Young, juvenile cougars are typically less productive and illicit a socially unstable population (Stoner, Wolfe, & Choate, 2006). In urban environments and fringe areas, this can lead to more human-cougar conflict and prey on domestic and farm animals (Hiller, Mcfadden-Hiller, Jenkins, Belant, & Tyre, 2015; Stoner, Wolfe, & Choate, 2006; Teichman, Christescu, & Darimont, 2016). An abundance of younger cougars are more curious, lack experience, and are more likely to come into conflict with humans (Teichman, Christescu, & Darimont, 2016). Harvesting certain ages has been questioned for over 40 years; however, little has been done to change this practice (Beausoleil, Koehler, Maletzke, Kerston, & Wielgus, 2013).

Not only has harvesting targeted specific cougars, but it may be linked to reducing the current populations. After tracking mortality of cougars within Wyoming, research illustrated that survival rates of the animal have decreased since the reintroduction the wolf (Elbroch, Marescot, Quigley, Craighead, & Wittmer, 2018). The reintroduction of a protected competitor species and designed hunting season has increased the cougar mortality. Predation of kittens were higher during hunting season, as were adult starvation deaths, and mortality rates of adult cougars (Elbroch, Marescot, Quigley, Craighead, & Wittmer, 2018). Other studies on the hunting of cougars show that if hunting exceeds 40% of the population, significant impacts occur on the populations (Stoner, Wolfe, & Choate, 2006). Additionally, cougar harvesting has been positively correlated with cougar-human conflict (Teichman, Christescu, & Darimont, 2016).

Experts are encouraging new strategies to manage wildlife in order to mitigate and protect the species (Beausoleil, Koehler, Maletzke, Kerston, & Wielgus, 2013; Maletzke, et al., 2017; Kerston, Spencer, & Grue, 2013; Moss, Alldredge, & Pauli, 2016). However, little has been done to change the methods of managing cougars at the state and federal level. Researchers are promoting a shift from reactionary to preventive methods to ensure less encounters, but little has been realized so far (Cougar Management Guidelines Working Group, 2005).

Although urban areas and populations are growing and expanding into cougar habitats, and cougars' habitats are coinciding with urban areas, little has been done by planners and zoning officials to mitigate the future or current interactions and occurrences. With literature from conservationists and wildlife managers that suggests an

increase in the frequency of human-cougar interactions and the use of urban areas by cougars, planners and zoning officials can use policy to help protect both residents and the broader ecosystem. The combination of green infrastructure movements, current management techniques, urban expansion, animal behavioral changes, land conservation, and current policy suggest urban areas will inhabit the current cougar habitat and that may facilitate the inclusion of the large cat in urban areas. Yet, little has been researched on the of role planning departments in mitigating interaction and improving the co-existence with cougars in these rapidly growing environments.

The standard state management techniques appear to have little effect on cougar-human interactions and more emphasis responding to high-profile cases. Because little to no policy has been created by planners, they must use expert recommendations, which will permit them to create policy protecting and promoting co-existence. While current methods focus on harvesting and removal of problem individual species, it may be necessary to focus on human elements, urban landscapes, and policies. Properly addressing these issues would permit planners to create and review their own policies to better protect their wildlife, residents, and financial interests.

Wildlife connectivity is a strategy many urban areas are currently implementing. Identifying inhabitable areas for cougars where adequate food and space, may alleviate interactions. Wilkinson (2016) providing wildlife corridors focused on riparian areas, increasing native vegetation in those areas, and providing road fencing will help provide habitat without dispersing cougars into urban areas. These approaches could be placed with open space management plans, green infrastructure plans, green space conservation,

and parks plans. By directly incorporating habitats that cougars desire they could remove the possible interactions. This coincides with Knopff, et al (2014) as they suggested providing edges and connected forests. These areas are the primary habitats and are often used by cougars during the day (Knopff, Knopff, Boyce, & St. Clair, 2014). Moss, et all (2016) also suggests using the buffers near urban areas to provide habitat alternatives.

Planners could also increase human density in environments to deter cougars. Maletzke, et al (2017) studied the effects of human density on cougars and identified an urban threshold. Their findings discovered that cougars in different habitats had different responses to urban areas. Cougars within drier climates with less dense vegetation had a lower density threshold, while cougars within dense vegetation areas provided more coverage for stalking and allowed higher density thresholds. From these findings they identified that cougars used wildland areas 79% of the time and densities ≤ 76.5 of were more likely to be used (Maletzke, et al., 2017). Planners could use this information to recommend or provide requirements of cluster development in fringe areas. By promoting this development, planners could both meet the density number and provide areas for cougars to traverse in corridors between developments. Kerston, et al (2011) also suggested that providing concentrated residential development could deter cougars. Subdivisions with clusters of 10 homes / ha would maximize wildland area and minimize habitat fragment. This would provide movement corridors and likely reduce interactions (Kerston B. N., Spencer, Marzluff, Hepinstall-Cymerman, & Grue, 2011). Development in rural and suburban areas within cougar habitats can increase encounters (Cougar

Management Guidelines Working Group, 2005), which reinforces developing at higher densities and maximizing opens pace.

When cougars do enter urban environments, the interaction rates have been shown to be quite rare at 1.6 interactions per 1,000 days. This was found by Kerston, Spencer, & Gure (2013) when monitoring over 32 cougars by radio monitoring devices. Additionally, Ninety-three percent of the cougars they monitored from 2003-2008 entered a residential area. They were primarily found in exurban and suburban areas of Washington State. In these areas, there was a significant amount of landscape coverage. Planners could use this information to require or inform landscaping ordinances. By eliminating low-lying plants near or around suburban areas cover for cougars could be limited (Cougar Management Guidelines Working Group, 2005). Additionally, planners and building codes officials could provide strict enforcements on areas underneath porches, elevated stairwells, and under-spaces. By eliminating areas where cougars could stalk prey, they would have a could reach their density threshold quicker as suggested by Maletzke, et al (2017). Some plants may also attract ungulates, like deer, to urban areas. Providing residents with a guideline of plants that may discourage ungulates may help mitigate encounters (Cougar Management Guidelines Working Group, 2005).

When cougars are in the urban environments, they avoid buildings and roads, leave kill sites faster, and abandon the area faster (Moss, Alldredge, & Pauli, 2016; Knopff, Knopff, Boyce, & St. Clair, 2014). Because they spend less time stalking for prey in these environments, they have changed their patterns of hunting and the types of prey they consume. Now they are often preying on domestic pets, synanthropes, and

roadkill (Knopff, Knopff, Boyce, & St. Clair, 2014; Cougar Management Guidelines Working Group, 2005). Knowing that cougars may prey on these animals, planners should make efforts to ensure the safety of residents by discouraging roaming pets and improper waste management. Planners could enforce tethering restrictions, leash laws, waste ordinances, and require the pickup of dead carcasses. Many high-profile cougar attacks have resulted from them attacking these animals. By proactively reducing the abundance of prey and access to prey, planners could deter cougars. Coverings, high fencing, and electrical options over and around pet and livestock enclosures may reduce the opportunity for cougars to attack prey.

Another important element that most research has recommended is education and awareness. Planners should provide preventive information to livestock owners and encourage efforts to deter cougar predation (Cougar Management Guidelines Working Group, 2005). Some urban areas have hired non-profit and private organizations to lead educational workshops on cougar proofing a house and fencing. Residents should be notified of potential encounters and should be notified through signage at public parks, playgrounds, campgrounds, etc. (Cougar Management Guidelines Working Group, 2005). Some of this information is readily available and guidelines have been created to help modify behaviors through the Cougar Management Guidelines (2005).

These strategies should be adaptive and monitored to assess the success. While state and federal agencies have jurisdiction in managing cougars, cities and urban governments can take preventive measures to decrease interactions with humans. By taking action and creating initiative, planners for urban environments can encourage

development, while maintaining a healthy cougar habitat and population without increasing the risk of hazardous encounters.

My research will analyze policy and infrastructure efforts to mitigate encounters with cougars in urban environments. Using the recommendations currently provided by the most recent literature, reviewing and assessing current methods or policy to reduce encounters by planners, and understanding the perceptions of practicing planners in those urban environments, I determined appropriate methods for the selected urban environments.

CHAPTER THREE

METHODOLOGY

The purpose for initiating an assessment and analysis of current practices for mitigating and improving interactions between urban environments and cougars is to help ensure success in mitigation techniques of a potential rise in human-wildlife interactions. This process identified and analyzed current policy, current perceptions of used strategies and policy, and identified relations of success within current literature.

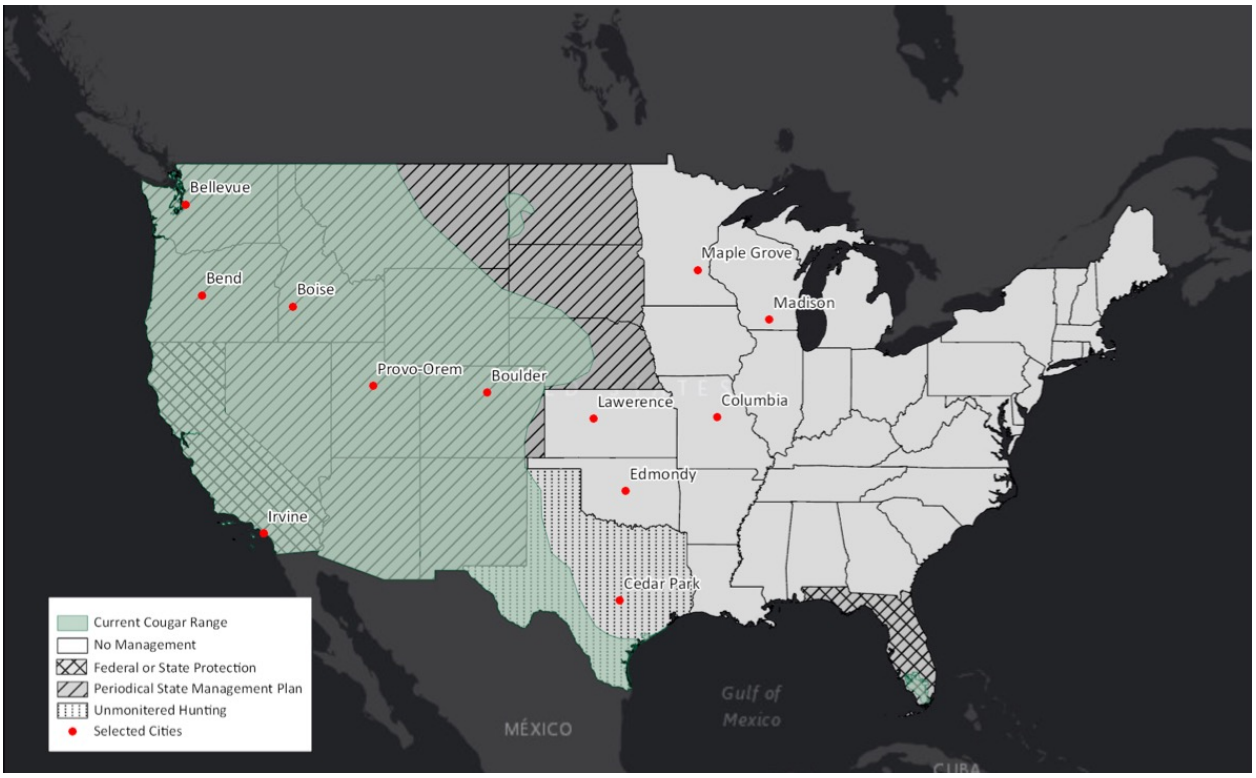
Survey Area and Participants

The cougar was selected as the primary study species because of several factors. Within the review of literature, researchers have found cougars to exhibit changes in habitat, diet, and behavior when exposed to urban environments. While cougars predominately avoid urban areas, they can be forced to use the environment because of these changes. The urban expansion within the large range of cougar habitat, coupled with the removal of habitat, has provided a motivation of assessing policy to manage and prevent cougar interactions with humans. Additionally, after a brief search of the recommended cougar management recommendations, it was apparent that little preventative management efforts have been provided by urban planners.

Using this information, coupled with the research of literature on habitat fragmentation, the study area included urban areas from the contiguous United States. The United States' economic stability, economic growth, and current policy all provided motivation for assessing policy affecting human-cougar co-existence. The areas in the United States within the cougar's current habitat was most appropriate for the study due

to the immediate threat to habitat and the increased opportunity for interaction with urban environments. In 2017, nine of the ten fastest growing states by percentage where located within the same state as the current cougar habitat (*Figure 3.1*).

Figure 3.1, Map depicting study areas and current cougar habitat



I selected urban areas from the U.S. Census Bureau's "City and Town Population Totals 2010 – 2017 (U.S. Census Bureau, 2018). I assessed the top 250 cities, of 50,000 or more residents, that have seen the largest percentage growth of population between those years. When selecting the urban areas, I separated each into two separate categories (see *Table 3.1*): urban areas within cougar state management or protection plans (UACSMP) or urban areas not within cougar state management or protection plans (UANCSMP).

Table 3.1, States with and without Cougar Management Plans

State Cougar Management Plans			
State	Plan	Year	Brief Summary
California	Yes	1990	Protected species according to Proposition 117, maintain population, minimize conflict, improve public awareness
Colorado	Yes	2004	Maintain populations, harvest, regional plans, minimize conflict
Idaho	Yes	2002	Maintain population, limit conflict, economic, harvest, protect habitat, research
Kansas	No	NA	NA
Minnesota	No	NA	NA
Missouri	No	NA	NA
Oklahoma	No	NA	NA
Oregon	Yes	2017	Maintain populations, manage conflict, harvest zones
Texas	No	NA	Open harvest
Utah	Yes	2015	Maintain populations and distribution, human safety, economic, harvest
Washington	Yes	2015	Maintain populations and habitat, minimize conflict, harvest
Wisconsin	No	NA	NA

After separating the cities based on that criteria, I assessed three variables each. For UACSMPs, I determined if they had a land preservation plan (habitat conservation, green space management, green infrastructure plans, open space management, etc.) and a high-profile cougar case occurring after 2010 (a cougar human interaction that made local news outlets consisting of direct contact with human, pet, or attack). Using that information, I selected cities with the highest population growth percentage (2010-2017) according to the United States Census Bureau. Once a state had a representing urban area, I choose not to select another urban area from that state. This was done to prevent over

representation in certain states, in hope that the study would cover a wider range of areas. For UANCSMPs, I selected urban areas from states with the most confirmed cougar confirmations since 1990 (Cougar Net, 2018) and adoption of a land preservation plan. After reaching 12 urban areas, 6 UACSMPs and 6 UANCSMPS, I completed the selection process. The urban areas are Bellevue, Washington; Bend, Oregon; Boise, Idaho; Irvine, California; Provo-Orem, Utah; Boulder, Colorado; Lawrence, Kansas; Edmond, Oklahoma; Cedar Park, Texas; Madison, Wisconsin; Maple Grove, Minnesota. The selection document can be seen on Table 3.2.

Table 3.2, Selected Urban Areas and their Criteria

	City	County	State	2010 – 2017 Pop. Grow %	Land Preservation Plan	High Profile Case(s)
Urban Areas within Cougar State Management Plans or Protection	**Bend**	Deschutes	Oregon	23.3	Yes	2018
	Bellevue	King	Washington	12.9	Yes	2018
	Boise	Ada	Idaho	8.7	Yes	2014, 2013, 2011
	Boulder	Boulder	Colorado	9.6	Yes	2018, 2017, 2011, 2008
	Irvine	Orange	California	30.8	Yes	2018, 2004(2)
	Provo-Orem	Utah	Utah	10.8	Yes	2018
	City	County	State	2010 – 2017 Pop. Grow %	Land Preservation Plan	State Confirmations since 1990
Urban Areas not within Cougar State Management Plans or Protection	**Cedar Park**	Williamston	Texas	38.3	Yes	57 (2nd)
	Columbia	Boone	Missouri	11.6	Yes	77 (1st)
	Edmond	Oklahoma	Oklahoma	13.3	Yes	27 (6th)
	Lawrence	Douglas	Kansas	10.4	Yes	20 (7th)
	Madison	Dane	Wisconsin	9.5	Yes	46 (3rd)
	Maple Grove	Hennepin	Minnesota	15.5	Yes	33 (4th)

Participants in this study included urban planners and state wildlife management agencies. Because the term urban planner and other occupations can represent a plethora of occupations, I identified individuals who manage, create, or monitor the current

implemented policy. The participants selected depended upon which agency created policies; however, the participants were from the implemented urban area and included county or city planners, zoning officers, urban wildlife management officers, etc. Additionally, interview participants were from state agencies as they manage, create, or monitor existing policy; therefore, they too were included amongst the participants to gauge their perceptions.

Data Collection

For the purposes of data triangulation, I collected three forms of data which included: primary documents, surveys, and interviews. The first form of data collection was electronic primary documents from the selected study area's urban environments (incorporated city and county). The primary documents included: amassing ordinances, comprehensive plans, community plans, zoning ordinances, websites, building codes, other ordinances, wildlife management guides, or any document that included information needed for assessment. If existing policy did not exist to mitigate human-contact, existing policies were assessed for current conditions of policy. The primary documents were organized to create an assessment matrix, Figure 3.3.

The second form of data collection was in the form of surveys. I digitally surveyed planners or other departments who implemented these plans on the perceptions of current policy and the creation of policy. The purpose of surveys was to compare planner perceptions of current policy to the assessment matrix's score. Questions matched each matrix assessment categories. See *Appendix A* for survey questions.

The third form of data collection was interviews. I interviewed, via phone, state wildlife managers and specialists. Each interview was recorded and transcribed using QuickTime software. The recordings and transcriptions were downloaded to a password-protected hard drive. The purpose of the interviews was similar to the survey assessment. Interviews were completed to compare with the assessment matrix's score and look to discern any discrepancies. See *Appendix B* for interview questions. Once primary documents, surveys, and interviews were collected, I began data analysis.

Procedures

The first step of the research process was to create a matrix assessment (Figure *3.3*). Using a comprehensive review of current literature, the matrix was created using methods from practicing planners, conservation biologists, urban planning researchers, and wildlife managers. After discerning an agreed upon criteria of methods to help "successfully" mitigate encounters between humans and cougars, the information was used to create the matrix assessment.

Once the assessment is created, the researcher will review and analyze each collected resource within the study area. These resources included comprehensive plans and ordinances. Using the template, the resources were reviewed and rated on potential of success. The assessment issued a Likert scale to determine what degree planners were attempting to prevent encounters with cougars. The scores were issued as followed for each category: 1 = Not mentioned, 2 = Mentioned but not specified for reducing encounters, 3 = Specified.

The assessment matrix categories were separated into two sections, intentional actions and non-intentional actions. Intentional actions include planning strategies that are explicitly to mitigate human-cougar interactions, i.e. notification and warning signage. The signage is used to notify residents and help mitigate the potential occurrence. Non-intentional actions are planning strategies that may be implemented without any intention to mitigating human-cougar interactions. While these planning strategies are without intention, they achieve the same desired outcome, mitigating human cougar interaction. For instance, cluster development is a common strategy to preserve open space and natural habitats. The strategy is commonly used; however, it is not intended to mitigate human-cougar interactions. This strategy according to the literature (Kerston, Spencer, & Grue, 2013; Maletzke, et al., 2017) this strategy may prevent cougars from interacting with humans.

Then subcategories were created to identify planning management techniques: Education and Outreach, Habitat Connectivity, Urban Ungulate Control, Notification and Warning Signage, Pets and Livestock Ordinances, Cluster Development, Building Requirements, and Greenspace Connectivity. These were selected based on the summary of the existing literature.

Examples Using the Assessment Matrix

To ensure that accurate scoring occurred, I will provide examples of some categories. For "Education and Outreach" to receive a 3 = specified, an urban government must provide awareness through notifications, educational programs, digitals pamphlets, etc. In Pasadena, California they have an example warning (See *Figure 3.2*)

displayed on their website and mention that it is located in parks and trails within the city limits. Additionally, they have held a series on educating residents on how to prevent encounters with cougars and what to do when encountering them. This educational series was provided by a private firm over the course of several weeks with prearranged meetings. The City of Pasadena had "specified" documents and actions that were aimed at educating the public and notified them of areas where they could encounter cougars, thus receiving a "3".

Figure 3.2, Example of Cougar Notification Flyer (City of Pasadena, 2018)

THIS IS MOUNTAIN LION COUNTRY

Mountain lions are part of the natural habitat of the Arroyo Seco, HOWEVER, they are wild predators and deserve your respect. BE AWARE AND CAUTIOUS. They have been known to attack without warning. You are advised to stay alert for potential danger. Do not hike alone.

Appearance:
Mountain lions are the largest of the predatory animals in Southern California. These reddish brown felines are the size of a large dog. Their ears are erect and slightly rounded. The most distinguishing feature of a mountain lion is their long tail.

Behavior:
Mountain Lions are primarily nocturnal but may hunt by day. They dine on deer and other wild animals including coyotes, raccoons and birds. Although rarely seen, mountain lions are feared for their carnivorous tendencies even though they prefer to stay away from humans.

IF YOU DO ENCOUNTER A MOUTAIN LION:

- **NEVER TURN YOUR BACK AND RUN FROM THE ANIMAL OR MAKE SUDDEN MOVES!**
- **Do NOT take your eyes off the lion's eyes. Do not approach the lion.**
- **Do not crouch down, don't look like prey.**
- **Stand tall and make yourself look as big as possible; put your hands over your head; open your jacket wide**
- **Pick children up so you appear to be one large person; place small children on your shoulders if you can.**
- **Hold your ground, make a lot of noise, shout!**
- **If the lion behaves aggressively, throw stones**

REMINDER: MINORS (Under 18 years of age) SHOULD BE UNDER ADULT SUPERVISION AT ALL TIMES

Please report any mountain lion sighting, including location and time of day, to a park worker as soon as possible or call City of Pasadena, Department of Public Works, Parks & Natural Resources Division, at (626) 744-4321.

The City of Highland Park in the suburbs of Chicago, Illinois would receive a score of "2" – Mentioned but not specified for reducing encounters. On their city website they provide a section titled "Co-existing with Wildlife". Within this section they

acknowledge that cougars had been sighted in nearby areas and to take caution. There is no mention of this posted within areas of the city, according to digital access, nor do they provide any measures by the city. While they provide a phone number to the Illinois Department of Natural Resources, they did not provide a specified reason for reducing encounters, thus receiving a "2". Any urban area that does not provide education or notification of cougars would receive a "1" – Not Mentioned.

Another example of a "3" – Specified would be Archuleta County in Southwest Colorado. In several of their plans they provide distinct mention of habitat connectivity and plans to provide habitat to several species including cougars. This is within their "Archuelta Community Plan", "Town-to-Lakes Plan", "Archuleta County Multi-Hazard Mitigation Plan". They also have conservation easement plans with direct mention of preserving habitat and have conducted critical habitat ranking study for the county. A city within the same county, Pagosa Springs, has also prioritized habitat by identifying areas cougar inhabit. They also provide highway analysis on crossings and objectives to preserve wildlife within their comprehensive plan.

The City of Redmond in Washington provides extensive insight on their objective to preserve greenspace and habitat connectivity. They discuss several methods in which they plan to connect habitats and mention plans of expanding and protecting habitat, streams, and forestry. However, these plans do not specify cougars or other wildlife when planning to conserve habitat. Thus, this would receive a "2" – mentioned but not specified for reducing encounters. Any urban area that does not provide a habitat

connectivity plan would receive a "1" – not mentioned. An example of the scoring can be found in *Figure 3.3*.

Figure 3.3, Example of Matrix Assessment

Urban Area	Intentional Actions					Non-intentional Actions			
City and surrounding area within a single incorporated county	Education and Outreach	Habitat Connectivity	Urban Ungulate Control	Notification and Warning Signage	Pet and Livestock Ordinances	Cluster Development	Building Requirements	Greenspace Connectivity	Landscape
	Are residents provided awareness through notifications, educational programs, digital pamphlets, etc.?	Does the area have, mention, or provide a plan to conserve habitat for the cougars?	Are there preventative methods or mention of reducing the number of ungulates within the area?	Does the area provide signage to warn or notify residents and users of areas inhabited, used, or occupied by cougars?	Are specific requirements or suggestions made to protect hobby animals, livestock, or pets from encounters with cougars?	Are development incentives, zoning requirements, public housing efforts made to ensure or promote development to protect habitat or movement corridors?	Do building codes require built form that protects residents from cougars? Are incentives provided to provide protection?	Are plans or objectives made or mentioned to provide residents with connected greenspace?	Are low-lying plants that provide hiding discouraged? Are residents provided information for plants that discouraging deer?
Irvine, California (Orange County)	3 (W)	2 (CP)	2 (WMP)	3 (W, O)	1	1 (ZC)	2 (BC)	2 (OMP)	1
Bend, Oregon (Deschutes County)									
Bellevue, Washington (King County)									
Boise, Idaho (Ada County)									
Provo-Orem, Utah (Utah County)									
Boulder, Colorado (Boulder County)									
Maple Grove, Minnesota (Hennepin County)									
Edmondy, Oklahoma (Oklahoma County)									
Lawerence, Kansas (Douglas County)									
Columbia, Missouri (Boone County)									
Maddison, Wisconsin (Dane County)									
Cedar Park, Texas (Williamston County)									

The next procedure I created a survey for each urban area (city and encompassing county). Planners and other professionals implementing the reviewed policy and strategies received a 16-question digital survey, encompassing a multi-response and Likert Scale question for all categories within the matrix assessment (see *Appendix A*). Likert Scale questions provided the following options: Not applicable, strongly agree, agree, neutral, disagree, strongly disagree. The Likert scale questions sought to determine the individuals' current perception of the policy. Additionally, the survey asked questions relating to the origin of the policy, support for the policy, and implementation

state of the policy, and success. This information was used to assess the professionals' perception of the policy and then in relation to the assessment matrix. These were multi-response questions provided potential responses encouraged from the above literature as well as an open-ended and N/A option.

Following the creation of surveys, I created an interview protocol. All twelve urban areas were contacted by email and telephone; however, only two of the twelve urban areas were interviewed (17% response rate). The protocol included individuals who monitor cougar populations, manage cougar populations, implement cougar policy, and/or interact with state and federal policies. The questions sought to identify common themes on issues such as the policy's effect on municipalities, agency interactions with local governments, and current trends for urban management. This information was used to assess how state management and policy are incorporated in urban areas.

Data Analysis

Overview

Primary Documents - Matrix. The first step in analysis was to analyze collected primary documents to complete the matrix. The primary documents included: comprehensive plans, zoning ordinances, building codes, open space management plans, parks plans, etc. Each matrix component received a score 1-3 as define above. Scores were used to evaluate to what degree urban areas are planning for cougar human interactions. The matrix was used for further analysis, described below.

Interviews. Interviews were transcribed for data analysis. After transcription, I coded for themes based on the matrix categories. Interview findings were used for further analysis, described below.

Level 1: Urban Area Matrix Assessment.

After organizing and collecting primary documents for matrix, I used the matrix assessment form to determine the success rating of each urban area's primary documents. An assessment and review were provided for each urban area. Data was analyzed both individually and grouped (UACSMP and UANCSMP). Within analysis, examples and reviews of primary documents were provided to convey success rating of each urban area's primary documents. The first level of analysis was determining the degree of success of each urban area's planning strategy to mitigate cougar-human interactions.

Level 2: Matrix Assessment with Professional Perceptions.

After completing the matrix assessment for each urban area and collecting surveys, I organized both forms of data and compared each matrix category to survey response of the selected urban area. This level of analysis was to compare each urban area's degree of success with correlated professional perceptions of strategies to support findings from the matrix assessment.

Level 3: Urban Areas with or without Cougar State Management Plans.

After examining individual urban areas, I divided the urban areas into two groups (UACSMP and UANCSMP) as defined above. I holistically examined all three forms of data for both groups to further understand my findings. The phone interviews were coded using a thematic analysis. This involved identifying segments of the interviews linked to

the planning strategies suggested by the literature and used to create the matrix assessment. Themes used for coding included: education and outreach, habitat connectivity, urban ungulate control, notification and warning signage, pet and livestock ordinances, cluster development, building requirements, greenspace connectivity, and landscape. By coding thematically, planning strategies were identified between planning perceptions, matrix assessment results, and interviews. However, only two participants were recorded. With a sample size of two, I could not generalize the interview findings. Instead, I treated them as anecdotal confirmation of what exists in the survey and matrix, and an anecdotal way to supplement the same.

CHAPTER FOUR

RESULTS

Level I: Urban Area Matrix Assessment

Scoring

Urban areas were assessed by primary documents (comprehensive plan, zoning ordinance, building code, open space management plan, parks plan, etc.) available through city, county, and state websites or associated social media accounts. Using the matrix assessment, each urban area was assessed for their planning strategies in nine categories (five intentional planning actions and 4 non-intentional actions). Each category received the following possible scores: 3 - Specified for reducing encounter, 2 - Mentioned but not specified for reducing encounters, 1 - Not mentioned. All explanations of scoring can be found above (*Chapter 3*). Findings from the assessment of each urban area using the rubric are described below.

Total Average Score

The selected urban area strategies for potentially mitigating encounters between humans and cougars averaged a score of 2.05 (*Table 4.1*). Seven of the selected urban areas received a score higher than 2. Six of those seven urban areas are within states that have a Cougar State Management Plan.

Table 4.1, Matrix Assessment - Total average score of all urban areas

City and surrounding area with a single incorporated county	Total Average Score Rankings
Boulder, Colorado (Boulder County)	2.78
Bellevue, Washington (King County)	2.67
Irvine, California (Orange County)	2.67
Boise, Idaho (Ada County)	2.44
Bend, Oregon (Deschutes County)	2.22
Provo-Orem, Utah (Utah County)	2.22
Madison, Wisconsin (Dane County)	2.00
Columbia, Missouri (Boone County)	1.89
Edmond, Oklahoma (Oklahoma County)	1.66
Cedar Park, Texas (Williamson County)	1.44
Maple Grove, Minnesota (Hennepin County)	1.44
Lawrence, Kansas (Douglas County)	1.33

In a broad sense, the results of the urban area current planning strategies evaluation suggest a need for specifying the use of strategies to cougar management. The average score for the six urban areas within state cougar management plans is 2.50; the average score for the six urban areas without state cougar management plans is 1.63, a .87 difference. Additionally, five of the urban areas received scores below 2, and all were in states without state cougar management plans.

Since only a few urban areas exhibit a significantly higher ranking, it can be presumed that direct planning efforts to mitigate for cougar-human interactions are not being described.

Intentional Planning Strategies Average Score

The disparity between urban areas with cougar state management plans and urban areas without cougar state management plans is apparent. Boulder, Colorado received a score 2 points higher than the lowest scoring urban area which was Lawrence, Kansas, conveying the largest range between scores. Geographically, these two areas are amongst the closest, yet had the largest difference in potential success of mitigating encounters.

Table 4.2 (Intentional Planning Actions Primary Document Scoring– Education and Outreach, Habitat Connectivity, Urban Ungulate Control, Notification and Warning Signage, Pet and Livestock Ordinances)

City and surrounding area with a single incorporated county	Intentional Actions Score Rankings
Boulder, Colorado (Boulder County)	3.0
Bellevue, Washington (King County)	2.6
Irvine, California (Orange County)	2.6
Boise, Idaho (Ada County)	2.4
Bend, Oregon (Deschutes County)	2.4
Provo-Orem, Utah (Utah County)	2.4
Madison, Wisconsin (Dane County)	1.6
Columbia, Missouri (Boone County)	1.6
Cedar Park, Texas (Williamson County)	1.4
Maple Grove, Minnesota (Hennepin County)	1.4
Edmond, Oklahoma (Oklahoma County)	1.2
Lawrence, Kansas (Douglas County)	1

When evaluating the degree of potential success based off intentional actions by planners (Education and Outreach, Habitat Connectivity, Urban Ungulate Control, Notification and Warning Signage, Pet and Livestock Ordinances), the results nearly mirror the total average score. Again, the six urban areas receiving the highest scores were within states with cougar management plans. The scores for intentional actions were Boulder, Colorado, receiving the highest score of 3, and Lawrence, Kansas receiving the lowest score of 1. These scores suggest urban areas with cougar state management plans plan to a higher degree for mitigating cougar-human interactions than states without cougar management plans. All urban areas without state cougar management plans received a score below 2. Half of the urban areas with state cougar management plans received scores higher than 2.5. The other half scored lower than 2.5 but higher than 2.

When assessing intentional actions, urban areas with cougar state management plans averaged a score of 2.57 while urban areas without state management plans averaged a score of 1.37. The range in scores is 1.19, signifying a larger gap between the urban areas.

Table 4.3, Non-Intentional Planning Actions Primary Document Scoring– Cluster Development, Building Requirements, Greenpeace Connectivity, Landscape

City and surrounding area with a single incorporated county	Non-Intentional Actions Score Rankings
Boulder, Colorado (Boulder County)	2.75
Bellevue, Washington (King County)	2.75
Irvine, California (Orange County)	2.75
Boise, Idaho (Ada County)	2.50
Madison, Wisconsin (Dane County)	2.50
Columbia, Missouri (Boone County)	2.25
Edmond, Oklahoma (Oklahoma County)	2.25
Bend, Oregon (Deschutes County)	2.00
Provo-Orem, Utah (Utah County)	2.00
Lawrence, Kansas (Douglas County)	1.75
Cedar Park, Texas (Williamson County)	1.50
Maple Grove, Minnesota (Hennepin County)	1.50

Non-Intentional Planning Strategies Average Score

When assessing non-intentional actions (cluster development, building requirements, greenspace connectivity, and landscape) by urban areas without state management plans received a score of 1.96. While the average score for non-intentional actions is under 2; therefore, there was an increase by .59 in comparison to intentional planning actions. Whereas, urban areas with state cougar management plans received an average score of 2.46, decreasing .11 in comparison to intentional planning actions.

The urban areas with the highest scores and highest quartile, were unchanged in all three categories: Total Average, Non-Intentional Actions, and Intentional Actions. Additionally, two of the urban areas which received the lowest scores, remained in the lowest quartile in all three categories.

Table 4.4, Matrix Assessment and Scores

Urban Area	Intentional Actions					Non-intentional Actions			
City and surrounding area within a single incorporated county	Education and Outreach	Habitat Connectivity	Urban Ungulate Control	Notification and Warning Signage	Pet and Livestock Ordinances	Cluster Development	Building Requirements	Greenspace Connectivity	Landscape
	Are residents provided awareness through notifications, educational programs, digital pamphlets, etc.?	Does the area have, mention, or provide a plan to conserve habitat for the cougars?	Are there preventative methods or mention of reducing the number of ungulates within the area?	Does the area provide signage to warn or notify residents and users of areas inhabited, used, or occupied by cougars?	Are specific requirements or suggestions made to protect hobby animals, livestock, or pets from encounters with cougars?	Are development incentives, zoning requirements, public housing efforts made to ensure or promote development to protect habitat or movement corridors?	Do building codes require built form that protects residents from cougars? Are incentives provided to provide protection?	Are plans or objectives made or mentioned to provide residents with connected greenspace?	Are low-lying plants that provide hiding discouraged? Are residents provided information for plants that discouraging deer?
Irvine, California (Orange County)	3 (W, GP, PP)	3 (GP, PP, OMP)	1	3 (W, SM, O)	3 (W, O)	2 (GP)	3 (W)	3 (OMP, PP, W)	3 (W)
Bend, Oregon (Deschutes County)	3 (W, GP)	2 (GP, O)	2 (W)	3 (SM, W)	2 (C, W)	2 (C, GP, O)	2 (C)	3 (GP, Other)	1
Bellevue, Washington (King County)	3 (W)	3 (OP, C, CP, W, CIP)	2 (Other)	3 (SM, W, Other)	2 (C.)	3 (GP, C)	2 (C)	3 (PP, NP, O)	3 (W, O)
Boise, Idaho (Ada County)	2 (OMP)	2 (W, GP, O, C)	3 (W, Other)	3 (OMP, W, C, SM, Other)	2 (C.)	3 (GP)	1	3 (W, GP, PP)	3 (C, W)
Provo-Orem, Utah (Utah County)	2 (OMP, PP)	3 (GP, C)	2 (W, C)	3 (SM)	2 (C, W)	2 (GP, O, C)	1	3 (GP, NP, PP, OMP)	2 (W)
Boulder, Colorado (Boulder County)	3 (W, UMP)	3 (W, C, GP, UMP)	3 (C, O)	3 (W, O, UMP)	3 (W, UMP)	2 (CP)	2 (W, O)	3 (PP)	3 (W, Other)
Maple Grove, Minnesota (Hennepin County)	1	1	2 (O)	1	2 (O)	2 (GP, Other)	1	2 (GP, Other)	1
Edmond, Oklahoma (Oklahoma County)	1	2 (PP, GP, Other)	1	1	1	2 (GP, O,	1	3 (PP, GP)	3 (W, O, Other)
Lawrence, Kansas (Douglas County)	1	1	1	1	1	2 (O, C)	1	2 (OMP, Other)	2 (W)
Columbia, Missouri (Boone County)	1	2 (GP)	2 (W)	1	2 (C, O)	2 (O, GP, NP, Other)	1	3 (GP)	3 (W)
Maddison, Wisconsin (Dane County)	1	2 (GP, OMP, O)	2 (W, O)	1	2 (O, W)	3 (O)	2 (O, W)	2 (OMP, PP)	3 (W)
Cedar Park, Texas (Williamston County)	1	2 (OMP, Other)	1	1	2 (O)	1	1	2 (OMP, Other)	2 (GP, W)

3 = Specified for reducing encounters, 2 = Mentioned but not specified for reducing encounters, 1 = Not mentioned

Key: Municipal Code (C), Comprehensive/General Plan (GP), Open Space Management Plan (OMP), Ordinance (O), Neighborhood Plan (NP), Website (W), Urban Wildlife Management Plan (UMP), Parks Plan (PP), SM (Social Media)

Primary Document Publication Dates

Primary documents (such as comprehensive plans, parks and recreation plans, open space management plans, etc.) reviewed were generally published/posted within the last five years (*Table 4.5*). Only three documents were published prior to 2010, while all other documents were published after 2010. Edmond and Oklahoma County, Oklahoma (General Plans both were last published in 2006) were currently updating these plans, during my research, but did not provide digital access when this study began. Ordinances' date of implementation varied substantially. For instance, Maple Grove implemented pet and livestock ordinances used for the matrix in 1984 and 2006. While the date of implementation varies for many urban areas, the ordinances were existing and mandated when the research was conducted.

Additionally, there does not appear to be a relation between cougar incidents and the publication of intentional planning strategies. The lack of relation between incidents and publication is most likely because many urban areas have had recent incidents (2017-2018) making it difficult to identify relations. However, one urban area, Boise, had incidents prior to 2014 and the publication of their primary documents after those events. While the primary documents' update could be a reaction to incidents, prior documents would need to be assessed to determine a relation.

Table 4.5, Matrix Assessment with Incident Dates and Publication Dates

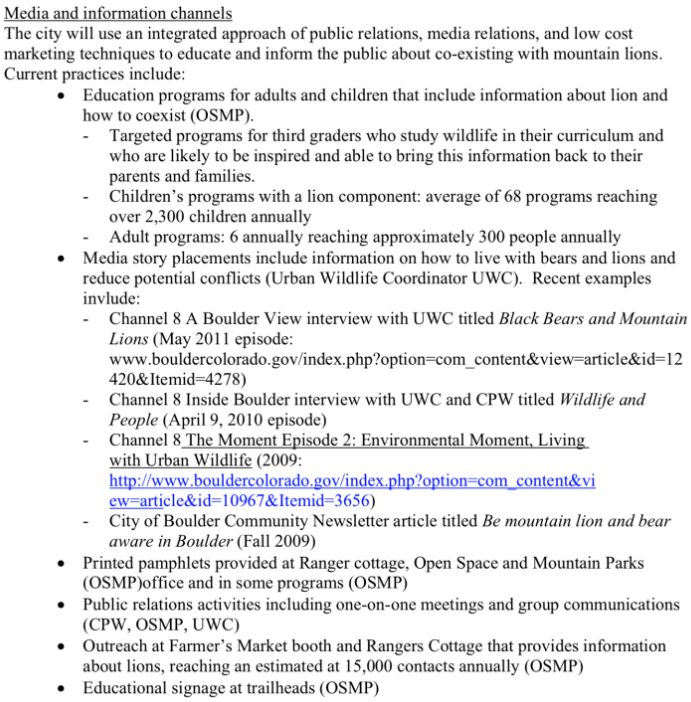
Urban Area		Intentional Actions Scores – Year Published					Non-intentional Actions Scores – Year Published			
City and surrounding area within a single incorporated county	Incident	Education and Outreach	Habitat Connectivity	Urban Ungulate Control	Notification and Warning Signage	Pet and Livestock Ordinances	Cluster Development	Building Requirements	Greenspace Connectivity	Landscape
Irvine, California (Orange County)	2018, 2014	3 W – 2018 GP – 2015 PP – 2018	3 GP – 2015 PP – 2018 OMP – 2012	1	3 W – 2018 SM – 2018 O – 2007	3 W – 2018 O – 1961	2 GP – 2015	3 W – 2018	3 OMP – 2012 PP – 2018 W – 2018	3 W – 2018
Bend, Oregon (Deschutes County)	2018	3 W – 2018 GP – 2016	2 GP – 2011 O – 1993	2 W – 2018	3 SM – 2018 W – 2018	2 W – 2018 C – 2018	2 GP – 2016 O – 2018 C – 2018	2 C – 2018	3 GP – 2016 OTHER - 2018	1
Bellevue, Washington (King County)	2018	3 W – 2018	3 PP – 2017 C – 1992 GP – 2017 CIP – 2018 W – 2018	2 OTHER – 2010	3 SM – 2018 OTHER – 2009 W – 2018	2 C – 1989	3 GP – 2017 C – 2009	2 C – 2006	3 PP – 2017 NP – 2010 O – 2008	3 W – 2018 O – 2016
Boise, Idaho (Ada County)	2014, 2013, 2011	2 OMP - 2015	2 W – 2018 GP – 2018 O – 2005 C – 2009	3 W – 2018 OTHER – 2015	3 OMP – 2015 W – 2018 C – 1997 SM – 2018 OTHER – 2015	2 C – 2017	3 GP – 2018	1	3 W – 2018 GP – 2018 PP - 2014	3 C – 2015 W – 2018
Provo-Orem, Utah (Utah County)	2018	2 OMP – 2017 PP – 2013	3 GP – 2015 C – 1999	2 W – 2018 C – 1998, 2017	3 SM – 2018	2 C – 1987 W – 2018	2 GP – 2015 O – 2018 C – 2018	1	3 GP – 2015 NP – 2015, 2018 PP – 2013 OMP – 2011	2 W – 2018
Boulder, Colorado (Boulder County)	2018, 2017, 2011, 2008	3 W – 2018 UMP – 2011 SM – 2018	3 W – 2018 C – 2006 OTHER – 2017 UMP – 2011	3 C – 2000 O – 2006	3 W – 2018 UMP – 2011 SM – 2018	3 W – 2018 UMP – 2011	2 GP – 2017	2 W – 2018 UMP – 2011	3 PP – 2014	3 W – 2018 OTHER – 2018
Maple Grove, Minnesota (Hennepin County)	NA	1	1	2 O – 2006, 1984	1	2 O – 1984	2 GP – 2018 OTHER – 2005	1	2 GP – 2018 OTHER – 2005	1
Edmond, Oklahoma (Oklahoma County)	NA	1	2 GP – 2006 PP – 2013 OTHER – 2018, 2012	1	1	1	2 GP – 2006 O – 2008	1	3 GP – 2006 PP – 2013	3 W – 2018 O – 2018 OTHER – 2018
Lawrence, Kansas (Douglas County)	NA	1	1	1	1	1	2 O – 2012 C – 2010	1	2 OMP – 2016 OTHER – 2015	2 W – 2018
Columbia, Missouri (Boone County)	NA	1	2 GP – 2013	2 W – 2018	1	2 C – 2017 O – 1964	2 O – 2017 GP – 2013 NP – 2010 OTHER – 2017	1	3 GP – 2013	3 W – 2018
Maddison, Wisconsin (Dane County)	NA	1	2 GP – 2018 OMP – 2018 O – 2014	2 W – 2018 O – 2002, 2018	1	2 W – 2018 O – 2012	3 O – 2014	2 W – 2018 O – 2014	2 OMP – 2018 PP – 2018	3 W – 2018
Cedar Park, Texas (Williamston County)	NA	1	2 OMP – 2015 OTHER – 2010	1	1	2 O – 2017	1	1	2 OMP – 2015 OTHER – 2010	2 GP – 2017 W – 2018

Categorical Analysis

Education and Outreach. Urban areas using education and outreach to reduce encounters varied in assessment. Six urban areas, all within states without management plans, received a 1. Four urban areas received a score of 3 and two received a score of 2. The average score for all urban areas is 1.83. The average score for urban areas with state management plans is 2.67 and urban areas without state management pans average 1. The range is abrupt and may signify urban areas without state management plans do not account for the species.

Urban areas scoring a 3 indicated educational programs or promoted cougar awareness to reduce encounters. Boulder's Urban Wildlife Management Plan exhibits a 3, "Educate and inform residents about mountain lion activity and behavior and ways to reduce attractive habitat on their property" (City of Boulder, 2011, p. 11). The plan includes a list of media outreach efforts ranging from formal education plan to brief videos on local news networks (*Figure 4.1*).

Figure 4.1, City of Boulder's outreach plan for Urban Wildlife (City of Boulder, 2011)



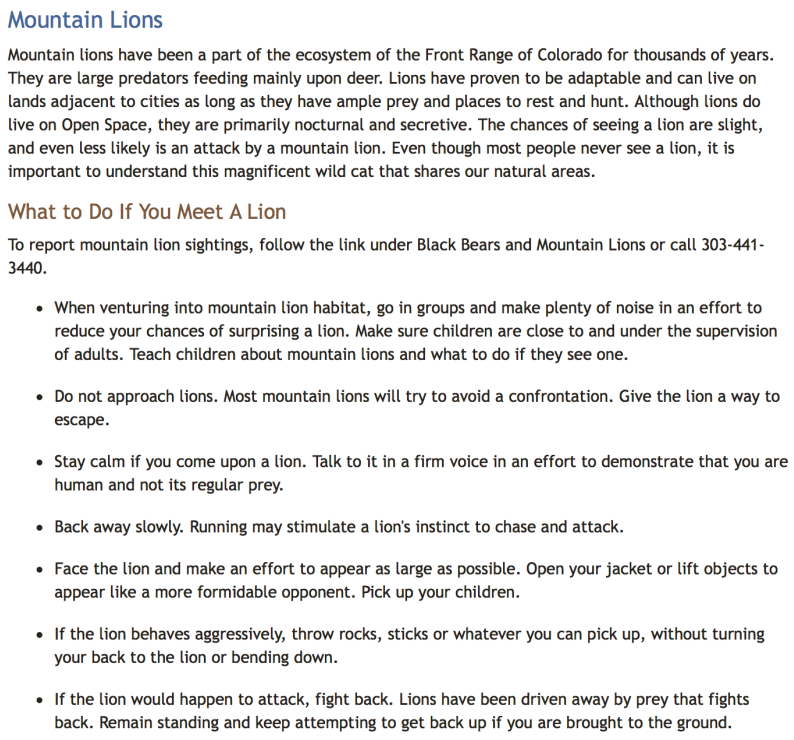
Media and information channels

The city will use an integrated approach of public relations, media relations, and low cost marketing techniques to educate and inform the public about co-existing with mountain lions. Current practices include:

- Education programs for adults and children that include information about lion and how to coexist (OSMP).
  - Targeted programs for third graders who study wildlife in their curriculum and who are likely to be inspired and able to bring this information back to their parents and families.
  - Children's programs with a lion component: average of 68 programs reaching over 2,300 children annually
  - Adult programs: 6 annually reaching approximately 300 people annually
- Media story placements include information on how to live with bears and lions and reduce potential conflicts (Urban Wildlife Coordinator UWC). Recent examples invlude:
  - Channel 8 A Boulder View interview with UWC titled *Black Bears and Mountain Lions* (May 2011 episode: www.bouldercolorado.gov/index.php?option=com_content&view=article&id=12420&Itemid=4278)
  - Channel 8 Inside Boulder interview with UWC and CPW titled *Wildlife and People* (April 9, 2010 episode)
  - Channel 8 The Moment Episode 2: Environmental Moment, Living with Urban Wildlife (2009: http://www.bouldercolorado.gov/index.php?option=com_content&view=article&id=10967&Itemid=3656)
  - City of Boulder Community Newsletter article titled *Be mountain lion and bear aware in Boulder* (Fall 2009)
- Printed pamphlets provided at Ranger cottage, Open Space and Mountain Parks (OSMP)office and in some programs (OSMP)
- Public relations activities including one-on-one meetings and group communications (CPW, OSMP, UWC)
- Outreach at Farmer's Market booth and Rangers Cottage that provides information about lions, reaching an estimated at 15,000 contacts annually (OSMP)
- Educational signage at trailheads (OSMP)

Additionally, the Boulder's website provides residents and visitors a brief synopsis of preventing encounters and an action plan when confronting a cougar (*Figure 4.2*).

Figure 4.2, City of Boulder's Mountain Lion education and awareness information on website. (City of Boulder, 2019)



Mountain Lions

Mountain lions have been a part of the ecosystem of the Front Range of Colorado for thousands of years. They are large predators feeding mainly upon deer. Lions have proven to be adaptable and can live on lands adjacent to cities as long as they have ample prey and places to rest and hunt. Although lions do live on Open Space, they are primarily nocturnal and secretive. The chances of seeing a lion are slight, and even less likely is an attack by a mountain lion. Even though most people never see a lion, it is important to understand this magnificent wild cat that shares our natural areas.

What to Do If You Meet A Lion

To report mountain lion sightings, follow the link under Black Bears and Mountain Lions or call 303-441-3440.

- When venturing into mountain lion habitat, go in groups and make plenty of noise in an effort to reduce your chances of surprising a lion. Make sure children are close to and under the supervision of adults. Teach children about mountain lions and what to do if they see one.
- Do not approach lions. Most mountain lions will try to avoid a confrontation. Give the lion a way to escape.
- Stay calm if you come upon a lion. Talk to it in a firm voice in an effort to demonstrate that you are human and not its regular prey.
- Back away slowly. Running may stimulate a lion's instinct to chase and attack.
- Face the lion and make an effort to appear as large as possible. Open your jacket or lift objects to appear like a more formidable opponent. Pick up your children.
- If the lion behaves aggressively, throw rocks, sticks or whatever you can pick up, without turning your back to the lion or bending down.
- If the lion would happen to attack, fight back. Lions have been driven away by prey that fights back. Remain standing and keep attempting to get back up if you are brought to the ground.

Examples of urban areas receiving a 2, provided outreach or educational tips without specifically mentioning reducing encounters with cougars. Boise's open space management plan promotes education and trail etiquette but does not specifically mention reducing encounters with Cougars, "Enhance trail head signage and education to assist new users and to explain responsible use behavior" (City of Boise, p. 44). Orem's "Parks, Trails, Recreation, and Open Space Plan" reiterates the same concept when addressing education on trail-safety; however, the plan does not mention reducing cougar interactions: "There was an indication in the survey that some respondents lack information about trails in the City. The 2010 Plan provides a comprehensive Education

Outreach Strategy, encompassing safety courses, programs, informational outreach, awareness events, supportive enforcement, evaluation strategies and policy guidance. This plan supports the implementation of those goals and objectives" (City of Orem, 2017, p. 33).

Habitat Connectivity. Urban areas using habitat connectivity varied in score as four received a 3, six received a 2, and two received a 1. The average score for urban areas using habitat connectivity to reduce encounters is 2.17. Urban areas with state management plans received an average score of 2.67 and urban areas without state management plans received a 1.67. All urban areas within state cougar management plans received a minimum score of 2, suggesting all account for habitat connectivity. The majority of urban areas without cougar state management plans are planning for habitat connectivity.

Urban areas receiving a score of 3, specifically account for habitat connectivity reducing encounters. Under the Mountain Lion and Bear Sections, Boulder's Urban Wildlife Management Plan "promotes and supports the protection of natural habitat along the numerous greenways and creeks running through town. The connectivity of the natural lands through and around the urban area provides movement corridors and habitat continuity for the many native wildlife species that wander into the city in search of food, water or cover." (City of Boulder, 2011, p. 8). Bellevue encompasses this category within their Park Codes: (3.43.070) Game refuge, sanctuary or reserve – Disturbance of wildlife. It is unlawful to enter any area in a park designated and posted by the city manager or his or her designee as a game refuge, sanctuary or reserve; or to molest or disturb wildlife or

the nest or breeding place of any wildlife located therein" (City of Bellevue, 2019). Additionally, King County's Capital Improvement Plan (CIP) suggests creating wildlife underpass and bridges to reduce encounters. First, it is displayed on the CIP Website:

> A wildlife underpass crossing structure will be placed beneath the new extension road (195th/196th Ave NE) to help reduce animal vehicle interactions and facilitate wildlife movements and connectivity of wildlife habitats. Currently, the cameras are capturing movements of wildlife in the vicinity of the new crossing to collect pre-construction baseline data. Once construction of the crossing has been completed, cameras will be permanently placed at the approaches to the underpass and inside of the crossing to document successful/unsuccessful passings, as well as comparing movements before and after construction (King County, 2016).

Figure 4.3, Image of underpass in King County to prevent wildlife-human interaction in roadways. (Seattle Times, 2015)

and then again on page ES35 of the project plan,

"Road crossings will be specifically designed to accommodate wildlife movement thus improving the safety of wildlife in the area. A 40-foot bridge over the new crossing of Stensland Creek would be constructed as part of the extension. The design will to allow passage of fish and various wildlife species, including large mammals such as deer, black bear, and cougar. In addition, the new bridge over Evans Creek on NE Union Hill Road would include a 12-foot- high clearance that would also facilitate the movement of wildlife in the area. (King County, 2010).

See Figure 4.3 and 4.5for construction of the crossing and imagery depicting wildlife using the crossing.

Figure 4.4, Example of wildlife using recently built wildlife crossing (King County, 2016)

Urban areas receiving a 2 did not explicitly mention the preservation of habitat connectivity in relation to preventing encounters. Edmond's website says, "Groupings of trees with wildlife value can provide food and shelter for local animals and insects. Groupings of trees also provide connectivity for wildlife in the green infrastructure network." (City of Edmond, 2019). Edmond's comprehensive plan also suggests the conservation for habitat without mentioning reduction in cougar encounters:

> "To help accomplish these goals, the primary conservation area immediately adjacent to the lake must be maintained in a full natural state, with no development except recreational or other compatible public uses. The secondary conservation areas, which include substantial natural wooded areas, should be preserved and utilized in site development. These areas should be preserved and protected through dedicated recreation or conservation easements when possible. Open space in the Lake District should be maintained through a coordinated and connected system of natural areas, greenways and recreational uses. Conservation subdivision techniques can be effectively used as a tool for utilizing and preserving natural areas and open spaces." (City of Edmond, 2007, p. 7).

Half of the selected urban areas convey a desire or need to protect habitat connectivity, but do not mention cougar encounters.

Urban Ungulate Control. Urban areas using ungulate control to prevent encounters may involve plans to remove deer within an area, scheduled plans for the removal of carcasses, and/or codes that require residents to report animal sightings. The total average score for all selected urban areas' uses of urban ungulate control is 1.83.

Urban areas with state management plans received an average score of 2.17, while states without a state management plan received an average score of 1.50. Only two urban areas received a 3. The majority of urban areas (six) received 2 and four urban areas had no mention of the removal of urban ungulates.

Figure 4.5, Image of cougar and deer near Boulder, Colorado (Denver Post, 2011)

The City of Boulder's "Urban Wildlife Management Plan Black Bear and Mountain Lion Component" addresses urban ungulates in their key messaging goals. This includes: "Citizens interested in reducing the chance that they could encounter a lion on their property can change landscaping to remove attractive resting and hunting areas, remove any attractants that may be drawing potential lion prey (deer) to their property" (City of Boulder, 2011, p. 28). Additionally, this plan provides a full text scholarly journal from Matthew W. Alldredge entitled "Cougars on the Edge", where he discusses the cougar attraction of deer and other ungulates into urban areas.

The six urban areas receiving a 2 provided numerous and variable control measures. Madison and Maple Grove attempt to prevent urban ungulates through public health, zoning, and animal control ordinances. Columbia, Missouri lists the transportation of wild animals and disposal of carcasses as responsibilities of the city park ranger, while Bend uses a similar program but operates through Bend Animal Control and Public Works via the "Sweeping Operations Plan".

Notification and Warning Signage. Similarly, to the "Education and Outreach" category, urban areas with state management plans appeared to have extensive planning strategies (average score = 3) and urban areas without state management plans and no planning strategies (average score = 1) to notify and warn residents/users.

Urban areas receiving a score of 3 provided several avenues for notification and warning signage to prevent cougar encounters. The urban areas scoring 3, all used social media to warn residents of potential cougar sightings, attacks, or presence (See *Figure 4.6*).

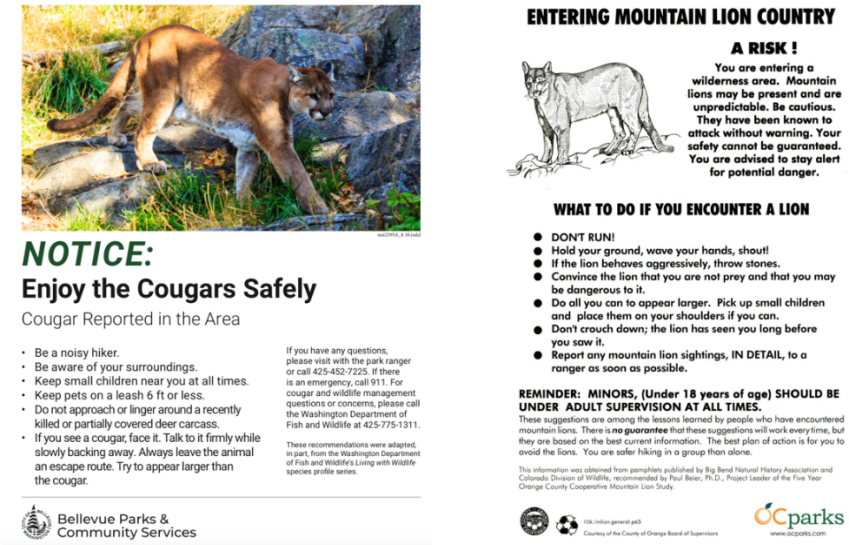
Figure 4.6, Examples of urban areas using social media to notify, educate, or warn residents of cougars within the area. (Facebook, 2019) (Twitter, 2019)

Some urban areas have designated strategies to prevent cougar-human interactions. Boise, Bellevue, and Boulder all provide description of notification plans and potential wildlife encounters in varying plans. Additionally, several urban areas use their websites to provide immediate press releases of cougar appearances via their police, public works, and animal control websites.

Some of the urban areas provide specific signage in parks and digitally via website. These appear not only warn residents of potential encounters but provide education and strategies of how to prevent encounters (see *Figure 4.7*). These urban areas sometimes include goals to improve signage, increase the quantity of signage, and have alternative notification systems. Within Boise's Interagency Plan they mention possible adding emergency phones at trailheads the language states, "A uniform public information and signage plan for trailheads and trails in the Foothills management area is needed to improve public safety and reporting of conservation challenges. An alternative

might be to provide emergency phones at trailheads" (City of Boise, 2015, p. 5.21). Another alternative mentioned was to use signage to keep residents/users out of protected areas in Bellevue and it states: "Limit or control human-introduced disturbances, including pets, hiking, refuse, and noise, in habitat patches. This may be accomplished with wildlife passable fencing, signage, or, preferably, a dense buffer of native vegetation" (City of Bellevue, 2009, p. 27).

Figure 4.7, Notification flyers in Bellevue, Washington and Orange County, California (City of Bellevue, 2018)



Pet and Livestock Ordinances. Included within intentional planning actions, pet and livestock ordinances had the highest quantity of urban areas scoring 2 (nine urban areas). When evaluating this category, urban areas used policy to prevent encounters with cougars. The total average score for policy preventing cougar encounters was 1.92. Two urban areas, Boulder and Irvine, received a 3 and two urban areas, Edmond and Lawrence, received a 1.

Boulder uses their Open Space Management Plan website to warn that it is "home to wildlife that could kill or injure your dog. Coyotes can be especially dangerous to dogs -- never let your dog run with coyotes even if they seem to be playing. The easiest way to keep your dog safe from coyotes is to keep your dog on-leash. Other animals that could pose a threat to your dog include black bears, mountain lions, porcupines, skunks and rattlesnakes. All of these animals are more likely to attack your dog if your dog is chasing them." (City of Boulder, 2019). Following this notification, the city provides recommendations and ordinances to protect pets while using this area. Boulder uses ordinances that consist of season leash restrictions, mandatory dog training programs, and licensing. These strategies are described as protective measures for both pets and people.

Many of the other urban areas utilize similar ordinances to protect dogs and people; however, they do not specify the potential hazards of cougar encounters. Maple Grove ensures livestock are sufficiently controlled by fencing and separated from residential uses up to 100ft within their Code of Ordinances (Code 1984, § 430:87). While this ordinance ensures potential prey for cougars is away from residential uses and properly contained, it does not refer to cougars nor any document on their website. This appears to be the general theme for urban area as they are preventing potential prey from being loose or near housing.

Cluster Development. Within this category, urban areas must utilize incentives or provide suggestions to ensure cluster development. This can be created through zoning, financial incentives, planned unit developments, and/or planning goals. The average of all studied urban areas uses of cluster development to prevent cougar interactions is 2.17.

The range of urban areas with and without state management plans is .3. Urban areas with state management plans averaged 2.3 and urban areas without state management plans averaged 2. Only three urban areas recorded a 3 (Madison, Bellevue, Boise). These areas received a 3 if cougar interactions were mentioned as a reason for clustering development or if the urban area mentioned creating habitat connectivity or space through clustering. This decision is because Kerston et al. (2011) described how movement corridors may reduce interaction. Additionally, rural, low density, development in cougar habitat is discouraged by the Cougar Management Guidelines Working Group (2005).

Within Bellevue's Land Use Code, they encourage development in already developed areas and away from critical areas or habitats (LUC 20.25H.045B). This in combination with incentive zoning, transfer of development rights, low impact development, and state mandated critical areas overlay districts help keep development out of potential habitats. Incentives and density calculators are provided to help ensure development in areas not affecting wild habitat or key sensitive areas. Boise similarly employs these techniques within their Neighborhood Design Policy and Comprehensive Plan. The city promotes cluster development patters to preserve corridors, natural features, and agricultural lands through the use of planned unit developments (3.26), building codes (11-07-09), and density bonuses. Boise also provides density bonus transfers "as a means of protecting sensitive areas by maintaining open space" (City of Boise, 2018, pp. FH-17). Madison uses an array of tools through their zoning ordinances to promote the protection of wildlife habitat. Dane County created several different

districts to promote development in specific areas. The county has a Conservancy District that is it "protect, maintain, enhance…seeking to assure protection of areas with significant topography, natural watersheds, ground and surface water, wildlife habitat, recreational sites, archeological sites, and other natural resource characteristics that contribute to the environmental quality of the County" (Dane County, 2012, pp. 10-43). Additionally, preservation of these areas is mentioned in the Transfer of Development Rights Receiving Overlay District, Transfer of Development Rights Sending Overlay District, and Planned United Development District.

Urban areas receiving a 2 employed many of these methods to encourage cluster development without the mention of habitat protection, wildlife corridors, or decreasing cougar-human interactions. For instance, Oklahoma County (Edmond) encourage cluster development to combat stormwater runoff and maintenance costs (Oklahoma County, 2008, pp. 8-24). Lawrence provides density bonuses when development projects protect sensitive lands in quantities greater than necessary (Oklahoma County, 2008, p. 74). Lawrence also sites that is necessary to preserve rural spaces, mitigate stress of infrastructure, and preserve open space; however, they do not mention habitat preservation (Dane County, 2012).

Building requirements. The Cougar Management Guidelines Working Group discuss how low-lying areas could provide appropriate habitat for cougars to hide and stalk for potential prey, and how building codes could prevent creating these spaces through the elimination of areas such as: underneath porches, elevated stairwells, and other under-spaces (Cougar Management Guidelines Working Group, 2005).

Additionally, planners and building officials could require covering, high fencing, electrical options, or specific lighting in rural environments. Under these criteria only one urban area within the study, used building codes or development suggestions to prevent human-cougar interactions.

Four urban areas use various portions of their zoning or building codes without intentionally planning to prevent human-cougar interactions. Dane County uses zoning ordinances to require setbacks of all animal accessories, which would separate potential prey for residential areas. Bellevue requires development in zoning areas containing critical areas to have buffer areas. These buffer areas are to provide conservation, clean water, and a large tract of native growth.

Orange County and Irvine received a 3 because they provide building and structural tips for pet owners on their website. The website suggests that owners should provide adequate fencing, eliminate access points on the top of pet enclosures, and enclose bottom of porches and decks all to deter wildlife (i.e. Mountain Lions). The County also suggests that if residents have "three life sustaining elements are available (food, water and shelter), you are likely to encounter some wildlife in your area" (Orange County, 2019).

Greenspace connectivity. Because a part of criteria for selecting urban areas required the area to have a greenspace, green infrastructure, or open space management plan these scores may appear higher. When evaluating the areas, urban areas had to exhibit a plan for green connectivity. If the plan mentioned green connectivity for habitat, reduction of wildlife interactions, or preservation of native areas the urban area received a

3. If areas promoted green connectivity without mentioning these, they received a 2. All urban areas received a 2 or higher in this category. The average of all urban area greenspace connectivity is 2.67. Urban areas with state management plans averaged 3, urban areas without state management pans averaged 2.33.

Provo and its incorporated county, Utah, exhibit a 3. Green connectivity and growth were mentioned in the general plan, area plans, neighborhood plans, and parks plan. Mentioned as an objective of the general plan, Utah County plans to "To protect areas of sensitive terrain, foliage, water features and wildlife habitat, the county should enforce ordinances prohibiting off-trail travel" and "Maintain the benefits of the historic satellite-greenbelt form of land use development policies" (Utah County, 2014, pp. 3-7). The Provo Parks Master Plan refers to the municipal code in its suggestion to "Preserve and protect wildlife habitat, species of special concern and their habitats, agricultural uses, historical and cultural features, scenic views, natural drainage areas and systems, and other desirable features of the natural environment, such as healthy long-lived trees, topography, notable plant communities, ground and surface water, wetlands, and riparian areas" (City of Provo, 2013, p. 73).

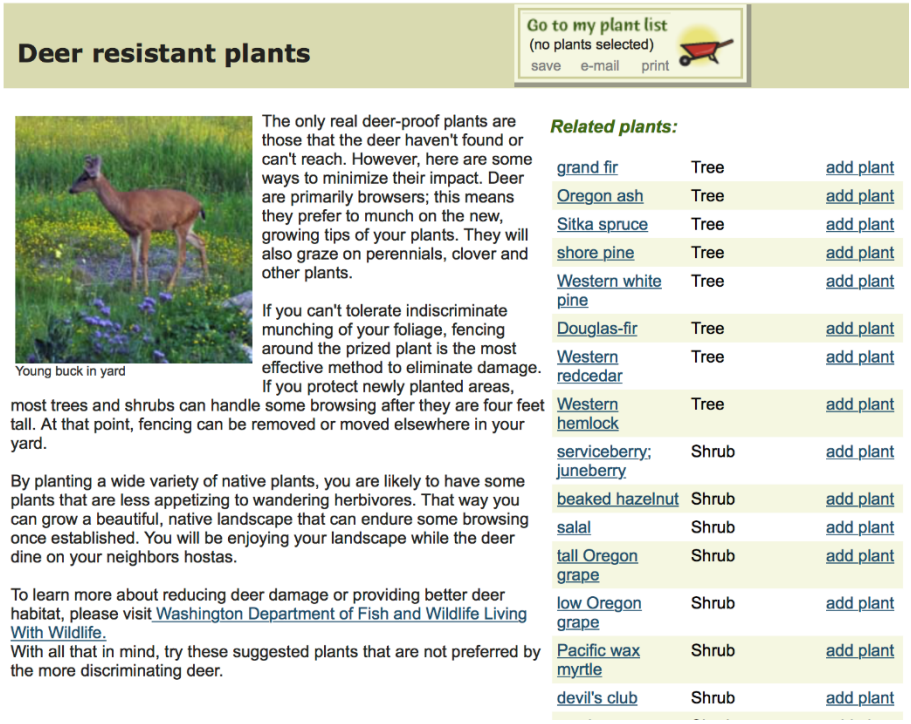
Urban areas receiving a 2 often refer to connectivity for residents. Madison's "Parks and Open Space Management Plan 2040" describes a key strategy as "increasing connectivity between parks to enhance access" (City of Lawrence, 2017, p. 121). Lawrence's comprehensive plan similarly has a goal that seeks to create "Connectivity To, From, and Between Park, Recreation, and Open Space Areas and Facilities" (City of Cedar Park, 2010, pp. 9-20). Cedar Park Texas uses their "Trails Master Plan" to promote

connectivity, “Where possible, trails corridors and alignments should be designed so as to enhance linkages between parks, neighborhoods, schools, retail, and key civic and community destinations. The citywide trail system is proposed to connect to other surrounding communities and other regional trail systems such as the Brushy Creek Trail through the southern portion of Williamson County.” (City of Cedar Park, 2010, p. 1.5). While these urban areas create connectivity plans of greenspace, they do not mention or suggest the use of habitat connectivity or preventing wildlife interactions.

Landscape. The urban areas that provide aid, suggestions, or information to help deter prey or places of hiding for cougars received a 3. Urban areas providing this material without mentioning of deterring cougars, prey, or wildlife interactions received a 2. The average score for all urban areas is 2.42. The difference between urban areas with state management plans and without is 0.17 (2.5, 2.33). Seven urban areas received a 3, three urban areas received a 2, and two received a 1.

King County and Bellevue, Washington use a plethora of resources to encourage and educate residents on how to discourage deer (see *Figure 4.8*). While the county acknowledges deer-proof plans may not exist, they do suggest mitigation techniques, less desired plants, and landscaping techniques (King County, 2013). The county also has free landscape plans for residents and developers to use. In addition to their own unique guide, they provide access to the Washington Depart of Fish and Wildlife to let residents understand how plants can create environments for an array of urban wildlife (King County, 2016).

Figure 4.8, King County website provides residents with deer resistant plant list. (King County, 2013)



Deer resistant plants

Go to my plant list
(no plants selected)
save e-mail print

Young buck in yard

The only real deer-proof plants are those that the deer haven't found or can't reach. However, here are some ways to minimize their impact. Deer are primarily browsers; this means they prefer to munch on the new, growing tips of your plants. They will also graze on perennials, clover and other plants.

If you can't tolerate indiscriminate munching of your foliage, fencing around the prized plant is the most effective method to eliminate damage. If you protect newly planted areas, most trees and shrubs can handle some browsing after they are four feet tall. At that point, fencing can be removed or moved elsewhere in your yard.

By planting a wide variety of native plants, you are likely to have some plants that are less appetizing to wandering herbivores. That way you can grow a beautiful, native landscape that can endure some browsing once established. You will be enjoying your landscape while the deer dine on your neighbors hostas.

To learn more about reducing deer damage or providing better deer habitat, please visit Washington Department of Fish and Wildlife Living With Wildlife.
With all that in mind, try these suggested plants that are not preferred by the more discriminating deer.

Related plants:

grand fir	Tree	add plant
Oregon ash	Tree	add plant
Sitka spruce	Tree	add plant
shore pine	Tree	add plant
Western white pine	Tree	add plant
Douglas-fir	Tree	add plant
Western redcedar	Tree	add plant
Western hemlock	Tree	add plant
serviceberry; juneberry	Shrub	add plant
beaked hazelnut	Shrub	add plant
salal	Shrub	add plant
tall Oregon grape	Shrub	add plant
low Oregon grape	Shrub	add plant
Pacific wax myrtle	Shrub	add plant
devil's club	Shrub	add plant

Similarly, Boulder's "Urban Forest Strategic Plan" describes measures taken to prevent wildlife. The plan mentions limiting use of fruit-bearing plants to prevent wildlife entering the city and offers alternative tree recommendations for development (City of Boulder, 2018, p. 36).

Urban areas receiving a 2 often had preferred plant lists or landscaping standards; however, they lacked any preventative methods for prey or potential human-cougar interactions. Cedar Park created ordinances mandating a preferred plant list (Sec. 14.07.011) but did not provide any description of plants and how they may or may not attack prey. Utah County supplies landscaping requirements by zoning but also does not mention the effectiveness or reasoning for such plants. Without specifically referring to

prey management it may be difficult for developers or residents to properly plan for such occurrences.

Level II: Matrix Assessment with Professional Perceptions

Survey

Of the twenty-four potential surveys distributed, I received seventeen responses. Ten of the urban areas were represented via survey, but Irvine and Lawrence were not represented. Six urban areas were represented by both county and city governments (Bellevue, Bend, Boulder, Columbia, Edmond, Maple Grove). One urban area was represented only by city (Cedar Grove) and three were represented by county government (Idaho, Orem-Provo, Madison).

Table 4.6, Matrix Assessment with an overlay of

"successful" and "unsuccessful" matches based on survey response.

Urban Area	Intentional Actions					Non-intentional Actions				Summary			
City and surrounding area within a single incorporated county	Education and Outreach	Habitat Connectivity	Urban Ungulate Control	Notification and Warning Signage	Pet and Livestock Ordinances	Cluster Development	Building Requirements	Greenspace Connectivity	Landscape	MATCH	NO MATCH	MATCH %	Missing Response
Irvine, California (Orange County)	3 (W, GP, PP)	3 (GP, PP, OMP)	1	3 (W, SM, O)	3 (W, O)	2 (GP)	3 (W)	3 (OMP, PP, W)	3 (W)	NA	NA	NA	X
Bend, Oregon (Deschutes County)	3 (W, GP)	2 (GP, O)	2 (W)	3 (SM, W)	2 (C, W)	2 (C, GP, O)	2 (C)	3 (GP, Other)	1	8	1	89%	✓
Bellevue, Washington (King County)	3 (W)	3 (OP, C, CP, W, CIP)	2 (Other)	3 (SM, W, Other)	2 (C.)	3 (GP, C)	2 (C)	3 (PP, NP, O)	3 (W, O)	6	3	67%	✓
Boise, Idaho (Ada County)	2 (OMP)	2 (W, GP, O, C)	3 (W, Other)	3 (OMP, W, C, SM, Other)	2 (C.)	3 (GP)	1	3 (W, GP, PP)	3 (C, W)	5	4	56%	X
Provo-Orem, Utah (Utah County)	2 (OMP, PP)	3 (GP, C)	2 (W, C)	3 (SM)	2 (C, W)	2 (GP, O, C)	1	3 (GP, NP, PP, OMP)	2 (W)	3	6	33%	X
Boulder, Colorado (Boulder County)	3 (W, UMP)	3 (W, C, GP, UMP)	3 (C, O)	3 (W, O, UMP)	3 (W, UMP)	2 (CP)	2 (W,O)	3 (PP)	3 (W, Other)	8	1	89%	✓
Maple Grove, Minnesota (Hennepin County)	1	1	2 (O)	1	2 (O)	2 (GP, Other)	1	2 (GP, Other)	1	7	2	78%	✓
Edmond, Oklahoma (Oklahoma County)	1	2 (PP, GP, Other)	1	1	1	2 (GP, O,	1	3 (PP, GP)	3 (W, O, Other)	9	0	100%	✓
Lawrence, Kansas (Douglas County)	1	1	1	1	1	2 (O, C)	1	2 (OMP, Other)	2 (W)	NA	NA	NA	X
Columbia, Missouri (Boone County)	1	2 (GP)	2 (W)	1	2 (C, O)	2 (O, GP, NP, Other)	1	3 (GP)	3 (W)	6	3	67%	✓
Maddison, Wisconsin (Dane County)	1	2 (GP, OMP, O)	2 (W, O)	1	2 (O)	3 (O)	2 (O)	2 (OMP, PP)	3 (W)	7	2	78%	X
Cedar Park, Texas (Williamston County)	1	2 (OMP, Other)	1	1	2 (O)	1	1	2 (OMP, Other)	2 (GP, W)	8	1	89%	X

	Successful match
	Unsuccessful match
	No response

Total Average	6.7	2.3	74%
Total Average (UACSMP)	6	3	67%
Total Average (UANCSMP)	7.4	1.6	82%

Urban Area Professional Perceptions with Matrix Assessment

All urban areas. All urban areas match, on average, 6.7 times per urban area providing a 74% match percentage (see *Table 4.6*). On average, urban areas do match 2.3 times per urban area. Two urban areas cannot be assessed due to lack of responses. Urban areas without both responses recorded significantly lower match percentages. Urban areas with both responses match 81.67%, while areas without both responses match only 64%, a difference of 17.67%. This most likely is occurring due to the primary documents selected from both county and city of each urban area. This also could suggest the match percentage may be higher than the current percentage.

Table 4.7, The total match percentage of each category within the matrix assessment.

	Education and Outreach	Habitat Connectivity	Urban Ungulate Control	Notification and Warning Signage	Pet and Livestock Ordinances	Cluster Development	Building Requirements	Greenspace Connectivity	Landscape	Average
Correlated	10	9	4	8	5	9	7	9	6	7.44
Lacked Correlation	0	1	6	2	5	1	3	1	4	2.56
Percentage	100%	90%	40%	80%	50%	90%	70%	90%	60%	74.44%

Category Match Percentage. The match percentage of the matrix assessment primary documents and survey responses match 7.44 times per category and do not match 2.56 times (see *Table 4.7*). Of the nine categories, six categories record match 70% or higher. Two categories match below 60%, “Urban Ungulate Control” and “Pet and Livestock Ordinances”. This could be a result of the department responsibilities, discrepancies between primary documents and government action, or the questions verbiage.

Bellevue, Washington (King County). King County. I received two responses from the urban areas, County and City. When reviewing the survey’s multi-ended responses

and the matrix assessment, the multi-response matched within six of the nine categories (67% match). Categories that matched are Education and Outreach, Habitat Connectivity, Notification and Warning Signage, Cluster Development, Building Requirements, Greenspace Connectivity. King County's primary documents (zoning ordinance) articulated zoning that promoted habitat connectivity for cougars, this was confirmed in the multi-ended responses. However, the responses illustrate a discrepancy under the category Landscape. Bellevue's website clearly displays a planting program and education of deer-attracting plants. This was not conveyed within either response of the survey as "None" was selected. Additionally, this is conveyed under the Likert scale question "Disagree" and "Not applicable". This could be contributed to differing department roles or user error.

Bend, Oregon (Deschutes County). Three responses were received, both County and City. Bend has the second highest match percentage (89%) with the matrix assessment of all respondents. All categories match except "Building Requirements". According to the matrix assessment, Bend and Deschutes County may require (pending water quality effects) extended setbacks for development near riparian areas, an ideal location for movement and hunting corridors (Wilkinson, 2016), of Deschutes River Corridor (City of Bend, 2016, p. 3). However, this is not conveyed in the survey responses as each respondent selected no strategies. This discrepancy could be represented by agency roles or lack of specificity within options on multi-response options.

Boise, Idaho (Ada County). Only one response was received for this urban area (county). Boise has a match percentage of 56% with five matches. These matches included accurate zoning for cluster development and greenspace connectivity plans. A discrepancy is apparent under the category "Notification and Signage". The matrix assessment review reports findings under the website, codes, social media, and other. The City of Boise provides detailed accounts of their notification and signage; however, without a response it was not recorded. This may also account for Urban Ungulate Control, Pet and Livestock Ordinances as examples for these categories were under the City of Boise.

Boulder, Colorado (Boulder County). Both respondents from Boulder County and the City of Boulder provided survey responses. Boulder also has the second highest match percentage (89%) and like Bend has discrepancy under Building Requirements. While examples are provided on their website and code, the respondents selected "None". Boulder's Urban Wildlife Management Plan acknowledges the importance of building modifications to prevent cougars in residential areas (City of Boulder, 2011) and their website provides insight into protecting pets with infrastructure changes (City of Boulder, 2019). This may be a discrepancy due to misinformation, differing department responsibility, or user error.

Cedar Park, Texas (Williamson County). Cedar Park's match percentage is 89% with matches in all categories but Urban Ungulate Control. Receiving a 1, there was no information found regarding the removal of carcasses; however, this was reported through the multi-response survey question. This could suggest some information is not

available digitally regarding all programs. While only one response is represented in the data, the low scores could account for the high match percentage. Because the urban area has low scores, without a full representation, it could skew the information to suggesting "None" is the accurate representation.

Columbia, Missouri (Boone County). Both county and city representatives provided survey responses. Columbia's match percentage of the matrix assessment and professional perception is 67%. The three categories that do not match are Urban Ungulate Control, Pet and Livestock Ordinances, and Landscape. For instance, the landscape category has a matrix score of 3; however, both respondents reported no preventive landscape measures (City of Columbia, 2019). The website reports an initiative to use native plants and educate residents of ways to incorporate plants, habitat advisors, and what those plants may provide for residents. The respondents report "not applicable" and "neutral" for the correlated Likert Scale questions. This may suggest a separate department, outside of respondents, is responsible.

Edmond, Oklahoma (Oklahoma County). The Edmond urban area reports the highest match percentage, 100%. While the urban area scores in the lowest quantile of the study area, both respondents' responses match the matrix recordings. Additionally, all Likert Scale questions are recorded with zero "not applicable" responses. This could suggest that the planning departments would be responsible for each category. An example of a successful match is "Greenspace Connectivity". Respondents proclaim tree preservation, trails plan, and zoning. These are all reported within the general and parks and recreation plans according to the matrix assessment.

Irvine, California (Orange County). There are no survey responses to compare with matrix results.

Lawrence, Kansas (Douglas County). There are no survey responses to compare with matrix results.

Madison, Wisconsin (Dane County). The urban area encompassing Madison has a 78% match through one survey respondent. This percentage is through successful matches of such categories as "Cluster Development" and "Greenspace Connectivity" in the Dane County primary documents. Two of the three non-matches are reported through the City of Columbia's. However, "Landscape" is reported through the City and County website. The City website directly provides reference through the Missouri's Department of Natural Sources to discourage urban wildlife such as deer (Wisconsin Department of Natural Resources, 2017). The County website provides links to the Wisconsin DNR "Yard Audit" checklist. The yard audit has checklist options correlating with the deterrence of predators such as coyotes, "Trim vegetation to reduce hiding places and potential denning sites" (Wisconsin Department of Natural Resources, 2017). Additionally, the one respondent reports "strongly disagree" that the planning department promotes this category. This is most likely because the actions are reported through a State agency.

Maple Grove, Minnesota (Hennepin County). Maple Grove also has a 78% match of categories within matrix and survey responses. Both County and City survey responses are recorded. Maple Grove scores in the lowest quantile of urban areas within the matrix assessment. Little evidence of primary documents is provided for planning strategies to

mitigate cougar-human interactions. This may be because the planning departments currently repots more than half of the categories as “Not applicable” within the survey (Habitat Connectivity, Livestock and Pet Ordinances, Building Requirements, Landscaping, Education and Outreach, and Notification/Signage). These categories are within both intentional and non-intentional planning methods. The survey responses confirm the assessment of primary documents in six categories. “Cluster Development” primary documents suggest density incentives and cluster development promoted in sensitive areas via zoning ordinances. These primary documents are confirmed through both County and City survey responses.

Orem-Provo, Utah (Utah County). The Orem-Provo has the lowest match percentage at 33% (3 matches). The urban area is lacking one survey response as Utah County provided the only response. The survey response reported “None” in all categories except “Landscape”. While a survey response is not provided by the City, several categories do not correlate with County primary documents. An occurrence of a non-match category is “Habitat Connectivity”. The recorded survey records “None” and “Disagree”. Within the matrix assessment, the general plan provided two instances of habitat connectivity specifically for cougars (Utah County, 2014, pp. 17, 23). This could suggest result of user error or discrepancies between actions and general plan.

Level III: Urban Areas with or without Cougar State Management Plans

Overview

Separating the survey responses into two categories, from above, the total number of participants is 17 (9 in UACSMP, 8 UANCSMP). All urban areas but Irvine, California and Lawrence, Kansas participated in the survey.

Not-Applicable Response Implications

In total, 24 responses in all categories were recorded as "Not Applicable". Of the 72 total responses in UACSMP, 15.27% are selected as "Not applicable" whereas 21.86% of UANCSMP total possible responses are selected as "Not applicable". This could imply that planners in both areas with and without state management plans perceive the planning strategies as not applicable to their department.

The planning strategies that received the most "Not applicable" responses were urban ungulate control, education and outreach, and notification signage. These responses were most likely due to urban areas without management plans do not recognize a subsiding cougar population, thus they do not see intentional planning strategies to mitigate cougar interactions as necessary. Increased cougar confirmations in these states (Cougar Net, 2018) and migrating populations, could suggest a future rise in predation of livestock/pets and human interactions. Providing preventive information to livestock owners and residence awareness is promoted by the Cougar Management Guidelines Working Group (2005) in areas with cougar populations.

Planning strategies that did not record a "Not applicable" response were all non-intentional categories (cluster development, building requirements, greenspace

connectivity, landscape). These results could imply that UANCSMP, while not having an acknowledged cougar population, have similar perceptions of these particular planning strategies as UACSMP. Therefore, strategies deemed as "non-intentional" were correct in their assessment as planning strategies not specific for cougar management.

The two types of urban areas have their largest discrepancies between the planner perceptions and "Not applicable" responses are Urban Ungulate Control (UACSMP 4: UANCSMP 1), Education and Outreach (2:4), and Notification and Signage (2:4). The latter two categories listed, are most likely associated with a lack of acknowledged population. However, Urban Ungulate Control is perceived as less of a planning matter in UACSMP than UANCSMP. This could suggest differences of regional planning requirements or different habitats provide different ungulate populations.

Group Categorical Likert Scale Assessment and Implications

Majority (see Tables 4.8 and 4.9). Each group illustrated a majority of responses in several categories in responding to the Likert-scale questions. Coupling "strongly agree" and "agree", the majority of responses are positive in Habitat Connectivity (51%) and Greenspace Connectivity (78%) for UACSMP. The majority of responses are positive in categories in Cluster Development (51%) and Greenspace Connectivity (93%) for UANCSMP. The majority of both urban areas group responses agreeing with planning strategies to promote greenspace connectivity is most likely in result of the urban area selection process (a criterion in selection process). The also suggests that these urban areas are properly providing corridors and connected habitats which could reduce

encounters of cougars (Knopff, Knopff, Boyce, & St. Clair, 2014; Moss, Alldredge, & Pauli, 2016)

Table 4.8, Urban Areas without Cougar State Management Plan Response Percentage

Questions	Total	Strongly agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly disagree (%)	Total
Education & Outreach	4	0%	0%	0%	75%	25%	100%
Habitat Connectivity	6	0%	0%	33%	67%	0%	100%
Urban Ungulate Control	7	0%	29%	14%	29%	29%	100%
Notification and Signage	4	0%	0%	0%	75%	25%	100%
Livestock/Pet + Building	5	0%	20%	0%	60%	20%	100%
Cluster Development	8	13%	38%	38%	13%	0%	100%
Greenspace Connectivity	8	13%	75%	13%	0%	0%	100%
Landscape	6	0%	17%	17%	33%	33%	100%

Additionally, each group of urban areas have a majority of responses with negative responses: “strongly disagree” and “disagree”. The majority of UACSMP responses with disagreement are Landscape (68%) and Livestock/Pet Ordinances – Building Requirements (71%). The negative responses for landscaping strategies does not correlate with the primary documents gathered for these urban areas. This could indicate that it may be a responsibility of the planning department or the primary documents to not align with actions of the department.

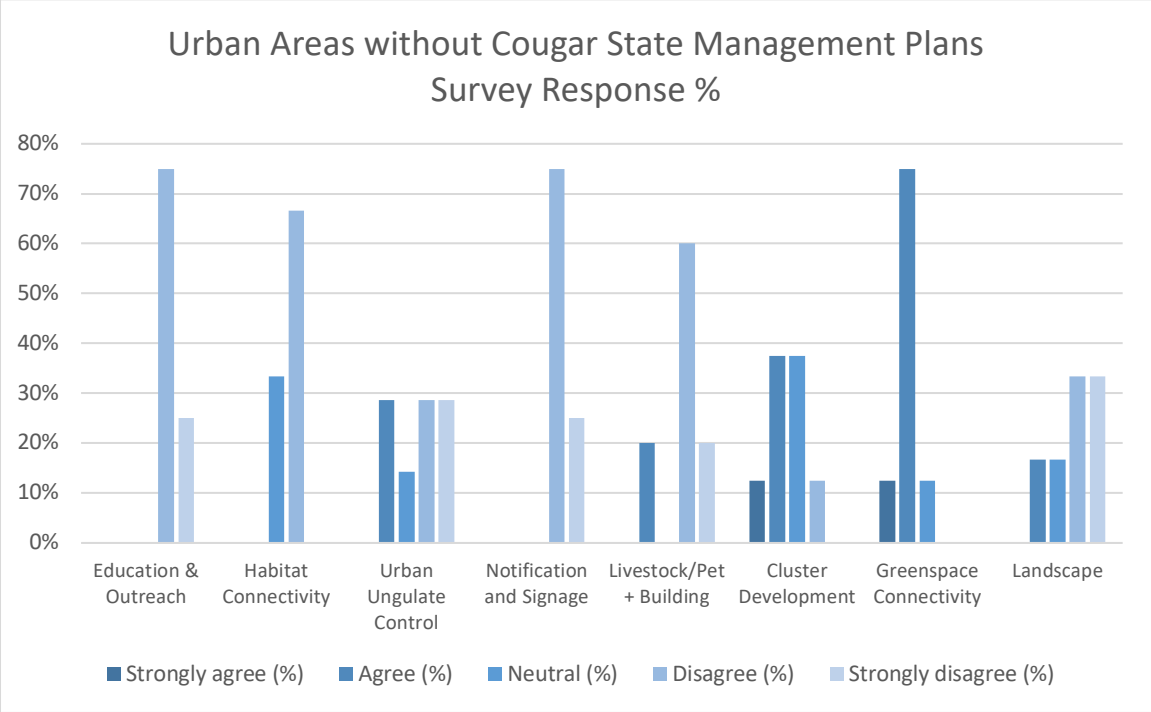
UANCSMP with negative responses as the majority are Education and Outreach (100%), Habitat Connectivity (67%), Urban Ungulate Control (58%), Notification and Warning Signage (100%), Livestock/Pet Ordinances – Building Requirements (80%), and Landscape (66%). UANCSMP planner perception appears to agree with the matrix assessment findings with seven of the nine categories not being promoted by their

departments. The negative responses and primary documents suggest planners in these urban areas are not using the planning strategies to mitigate human cougar interactions. The implication of not using these strategies could include predation of livestock and pets, uninformed residents, and an increase in prey.

Table 4.9, Urban Areas with Cougar State Management Plan Response Percentage

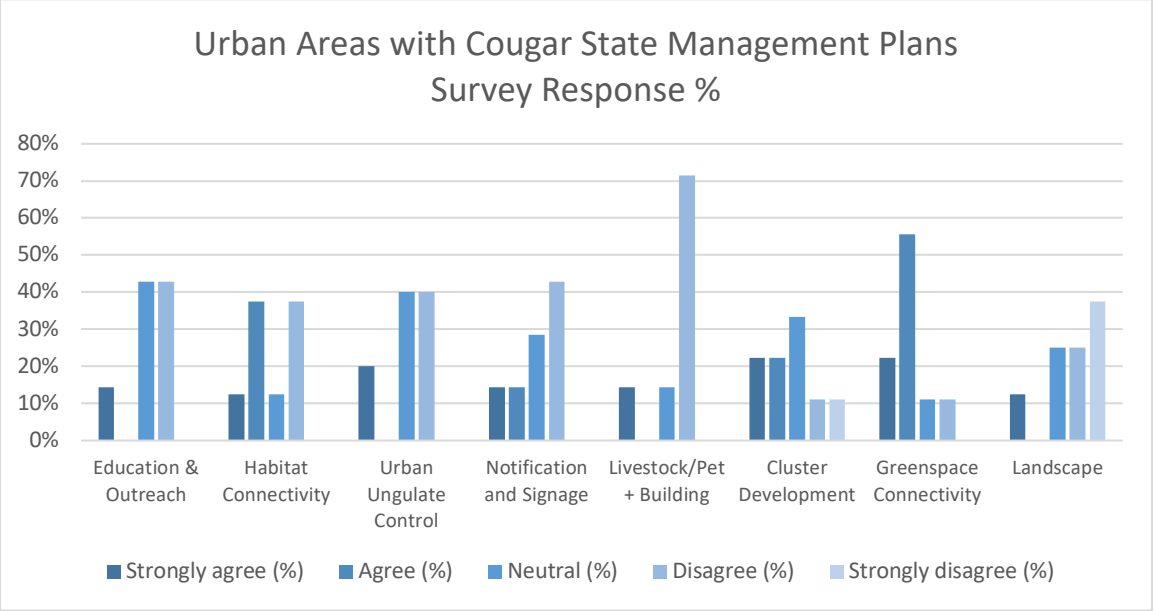
Questions	Total	Strongly agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly disagree (%)	Total
Education & Outreach	7	14%	0%	43%	43%	0%	100%
Habitat Connectivity	8	13%	38%	13%	38%	0%	100%
Urban Ungulate Control	5	20%	0%	40%	40%	0%	100%
Notification and Signage	7	14%	14%	29%	43%	0%	100%
Livestock/Pet + Building	7	14%	0%	14%	71%	0%	100%
Cluster Development	9	22%	22%	33%	11%	11%	100%
Greenspace Connectivity	9	22%	56%	11%	11%	0%	100%
Landscape	8	13%	0%	25%	25%	38%	100%

Table 4.10, Bar graph depicting response percentage of each category for UANCSMP.



Five of the nine UACSMP, had at least 20% of planner respondents select "Neutral". This response signifies a portion of respondents felt they neither agree nor disagreed that their department promoted the categories. In *Table 4.11*, respondents selected neutral 40% or more for Education and Outreach and Urban Ungulate Control. Because the population (N) is few in numbers this could be a result of discrepancies between urban areas. A lack of consistency within Urban Ungulate Control is consistent with Urban Ungulate Control under the matrix assessment as it was near an even distribution of score range.

Table 4.11, Bar graph depicting response percentage of each category for UACSMP.



Interviews. All twelve urban areas were contacted by email and telephone; however, only two of the twelve urban areas were interviewed (17% response rate). Because of the low response rate, generalizations cannot be made.

UACSMP had two participants. When interviewing participant 1 about the creation of management strategies, they discussed public outreach. For instance, participant 1 said "Extensive public outreach process that includes all stakeholders, lion hunters, in your case municipalities, municipalities if they need work" and again when asking about collaboration with urban planners "if there is open space… that has deer/elk, as part of our outreach process". Participant two reiterated the requirement and need for public outreach when asked about choosing methods for cougar management "We are a public agency so naturally we have to operate within established statutes and our own rules and policies. Because of that to we are enormously involved and engaged in the public's needs and desires.".

Mentioned above by participant 1, deer and elk populations may encourage communication between state agencies and local governments, but it also may exhibit the role of local governments and state agencies dealing with ungulates. While many state agencies may control the permitting process for hunting, Participant 1 referred to Urban Ungulate Control being difficult because "Some have robust deer and elk and lion populations and many cases, but not all, lion hunting is not a regulated activity on those municipalities owned lands, not always, so harvest is not an option there."

When asked about the evolution of urban areas relation with human-cougar interaction, Participant 1 also referred to the importance of outreach and education as urban areas continue to acquire more open spaces and natural areas, "I think that just making as many people that are using these municipality lands aware of the fact that when they are using these properties they are in wildlife habitat." Participant one also said "The municipality will often handle the education and signage, but they are still looking to us, as they should for the actual wildlife management side of it. This could imply as local governments acquire open space, urban planners will begin to deal with large predators such as cougars more frequently than in the past.

Participant 2 also described how management strategies by urban planners and state agencies can differ due to perceptions and expectations of the residents "because there is this really high-profile population where there are a lot of concerns of genetic inbreeding, lack of dispersal, emphasis on established corridors. Those are very different situations than most other places, people say look at this situation, they are trying to setup corridors, feeding programs, and turn away when they are doing some concerning

behaviors. But its apples to oranges, when you look at the situation." Describing how perceptions of cougars and the preservation of specific populations may affect management strategies could the wide disparity in some categories of the matrix assessment.

UANCSMP had no interview participants.

Limitations

The broad and over-encompassing nature of the study does provide elicit limitations. Attempting to generalize urban areas across the United States is difficult due to the varying habitats, state and federal laws, cougar populations, and resident perceptions. According to Maletzke et al. (2017), environmental effects create differing response rates for cougars in urban areas. For instance, cougars within Utah may have a very different density threshold than cougars in Washington. These natural environments could alter policy and planning strategies employed.

The breadth of the United States not only provides a varied number of habitats, but it also provides an array of different cougar populations. Cougar populations in California are estimated to be much smaller than some of the surrounding states. This could create differences in public perception of the species and differing expectations of management. California's statue protects the species, where all other states in this study currently permits harvesting. These variations could limit the research.

Additionally, the study has a low percentage of interview participants (17%) and could receive a better understanding had all urban areas been represented in the survey. A

higher response rate could yield more accurate and better understandings of the role of state agencies in urban areas.

Survey and interview questioning could be improved or adapted to help discern certain information or make more accessible to other local government officials in departments such as Parks and Recreation, Building and Codes, Public Works, etc.

CHAPTER FIVE

DISCUSSSION

Conclusions and Recommendations

Conclusions. Urban areas, in general, are implementing and using strategies to mitigate human-cougar interaction; however, most urban areas are not citing or referring cougar deterrence or prevention of interactions. Within the analysis, urban areas with state cougar management plans are implementing planning strategies better than urban areas without state cougar management plans. Urban areas within states with cougar management plans are currently providing education and outreach, habitat connectivity, notification and warning signage, greenspace connectivity, cluster development, and landscaping requirements to mitigate human-cougar interactions. By providing these strategies, urban planners are potentially mitigating human-cougar interactions.

Habitat connectivity and greenspace connectivity may provide cougar habitats and movement corridors that could deter interaction (Knopff, Knopff, Boyce, & St. Clair, 2014; Moss, Alldredge, & Pauli, 2016; Wilkinson, 2016). Additionally, by clustering development and increase density, planners may be providing a threshold were cougars are discouraged to enter (Maletzke, et al., 2017).

Planning strategies such as building requirements, pet and livestock ordinances, and urban ungulate control do not appear to be consistently promoted within planning departments and could promote potential prey for cougars. Policy not securing livestock/pets or deterring potential prey could attract more cougars. Blech, Boone, & Alldredge's (2018) research suggested that the reduction of habitat and dispersal of prey

could attract cougars. Additionally, Moss, Alldredge, and Pauli (2016) found that cougars altered their diet to more urbanized species when their natural prey was dispersed. Without policy and planning strategies to protect pets, livestock, and urban ungulates urban areas could see an increased presence of cougars.

Intentional planning actions to mitigate cougar interactions are not apparent in urban areas without state management plans and display a clear gap between the two groups of urban areas; however, several categories of non-intentional actions are present. The lack of preventative education and information to livestock owners could allow for eventual predation as populations of cougars increase (Cougar Management Guidelines Working Group, 2005).

The matrix used to evaluate primary documents from each urban area was created using current literature and best practices according to researchers and wildlife management professionals. According to urban planners' current perceptions and planning practices, the matrix is an appropriate evaluation tool. The match percentage of the matrix and planner survey is 74% and may have been higher had participation of survey been greater.

Recommendations. For urban areas to be more successful they should provide a more education and awareness for residents of several categories. The City of Boulder acknowledge requiring pet owners or home owners to create structural changes for housing could be difficult (City of Boulder, 2019). However, urban planners could provide a template similar to King County (see *Figure 4.8*) to encourage built form changes. While not changing the code of zoning, urban planners could provide residents

with recommendations and education on how to protect pets and themselves through development, building infrastructure, and design suggestions.

For urban areas acquiring open space, promoting greenspace connectivity, and creating corridors of habitat connectivity more mitigation of urban ungulates may be needed. Relatively low scores on the matrix indicate urban ungulates (potential food sources for cougars) may become more present in urban areas. According to matrix assessment, interviews, and surveys this is a limitation of urban areas attempting to mitigate human-cougar interaction. Providing dead carcass programs, harvesting, appropriate vegetation, feeding ordinances, and awareness campaigns in urban areas may help prevent this food source becoming abundant.

Future Research and Implementation. Employing the matrix on a more localized level may help prevent some of the limitations mentioned above. The assessment can be used to identify urban areas within a specific state that may need to incorporate more localized perspective of planning strategies to combat this study's limitations.

States could use the matrix for annual reviews of their county or municipal governments. Similarly, to the BearWise initiative, urban areas and planners could apply and receive accreditation of promoting planning strategies that help residents live responsibly with cougars using the matrix (BearWise, 2019).

To further gauge the implementation of each urban area's planning strategies and policies, further research could assess residents' perceptions of the planning strategies.

Finally, future research could attempt to determine if the urban areas receiving higher scores, actually mitigate encounters from a quantitative approach.

APPENDICES

Appendix A

Digital Survey

Planning for Cougars in an Urban Environment

During this survey the word cougar refers to the large felid that is also referred to as: mountain lion, catamount, panther, and puma.

* Required

Part 1

For what state do you work?

Mark only one oval.

- California
- Colorado
- Idaho
- Kansas
- Minnesota
- Missouri
- Oklahoma
- Oregon
- Texas
- Utah
- Washington
- Wisconsin

For whom do you work? (please select all that apply) *

Mark only one oval.

- City
- County
- State
- Federal
- Other:

Part 2: Environmental Planning Approaches

Please rate your level of agreement with the following statements.

My department encourages cluster development. *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree
- Not Applicable

My department encourages green or open space connectivity. *

Mark only one oval.

- Strongly disagree

- Disagree
- Neutral
- Agree
- Strongly agree
- Not Applicable

My department promotes and attempts to protect habitat connectivity or habitat conservation for cougars. *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree
- Not appicable

Please select all that apply

Which of the following policies and actions, if any, does your department employ to encourage cluster development. *

Check all that apply.

- Policy revisions
- Zoning ordinances
- Density incentives
- Goal setting
- None
- Other:

Which of the following actions does your department employ to encourage green or open space connectivity? *

Check all that apply.

- Goal settings
- Tree preservation
- Greenspace connectivity plan
- None
- Other:

Which of the following policies and actions, if any, does your department employ to create habitat connectivity or habitat conservation for cougars? *

Check all that apply.

- Land or open space management plans
- Tax incentives for private land owners
- Public-private land partnerships
- Zoning
- Collaboration with other governments

- Goal setting
- Land acquisition
- Donations
- Easements
- Other
- None

Part 3: Predator Prey Interaction

Please rate your level of agreement with the following statements

My department provides urban ungulate control or the removal of carcass/roadkill from urban environments. *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree
- Not applicable

My department provides education or policy to protect hobby animals, livestock, or pets from encounters with predators. *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree
- Not applicable

My department encourages or requires residents to implement landscaping that deters the presence of deer, cougars, bears, and/or other animals. *

Mark only one oval.

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly Disagree
- Not applicable

Please select all that apply.

Which of the following services and policies, if any, does your department provide to control urban ungulates and or carcasses/roadkill? *

Check all that apply.

- Carcass removal program
- Physical infrastructure (fencing, etc.)

- Management plans
- Deer culling
- Ordinances (no feeding)
- Other
- None

Which of the following policies and actions, if any, does your department provide to protect hobby animals, livestock, or pets from encounters with predators? *

Check all that apply.

- Ordinances
- Building requirements
- Zoning
- Education and outreach
- Other
- None

Which of the following policies, if any, does your department use to encourage landscaping that deters presence of deer, cougars, bears, and/or other animals? *

Check all that apply.

- Ordinances
- Zoning
- Other
- None

Part 4: Education and Outreach

Please rate your level of agreement with the following statements.

My department provides education and outreach to inform residents of living with cougars. *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree
- Not applicable

My department provides notification and signage in areas with the occurrence, inhabitance, or potential presence of cougars to notify or warn residents/users. *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree
- Not applicable

Please select all that apply

Which of the following does your department promote/conduct to inform and educate residents of cougars? *

Check all that apply.

- Notification systems
- Recurring education programs
- Digital or physical pamphlets
- Videos
- Web page
- Social media
- Other
- None

Which of the following does your department provide to notify or warn residents/users of areas inhabited, used, or occupied by cougars? *

Check all that apply.

- Onsite signage
- Social media
- Digital notification
- Website
- Other
- None

Appendix B

Interview Protocol

Interview Questions

1. Does your state recognize a cougar population subsisting within the area?
2. How did your state determine that it needed to make a large predator (i.e. cougar) management plan? What are the circumstances that caused the need?
3. What are your current recommendations for large predator (i.e. cougar) management?
4. How did your state choose the current methods for large predator (i.e. cougar) management?
5. How does your state measure success in large predator (i.e. cougar) management?

6. Do you currently collaborate or work with urban planners when creating or implementing your management plans?
    a. If yes, how would you describe your collaborations with urban planners?
    b. If no, how would urban planners' collaboration impact your management planning efforts?
7. If you do work with urban governments (city, county, town, etc), how did the collaboration evolve? What precipitated it?
8. Under what circumstances have urban governments contacted your department for support with large predators (i.e. cougar)?
9. Are there any other issues or aspects of cougar management in urban areas in your state which I did not mention or discuss that might inform better practices?

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